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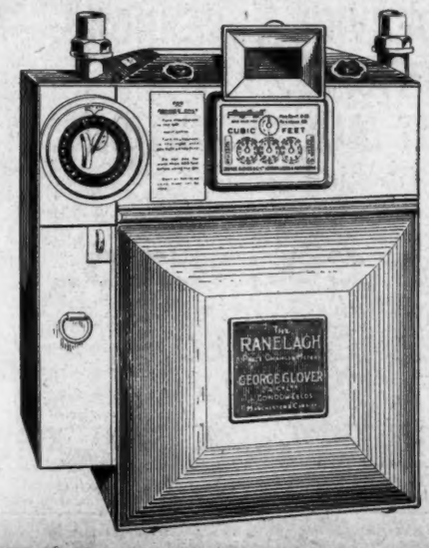

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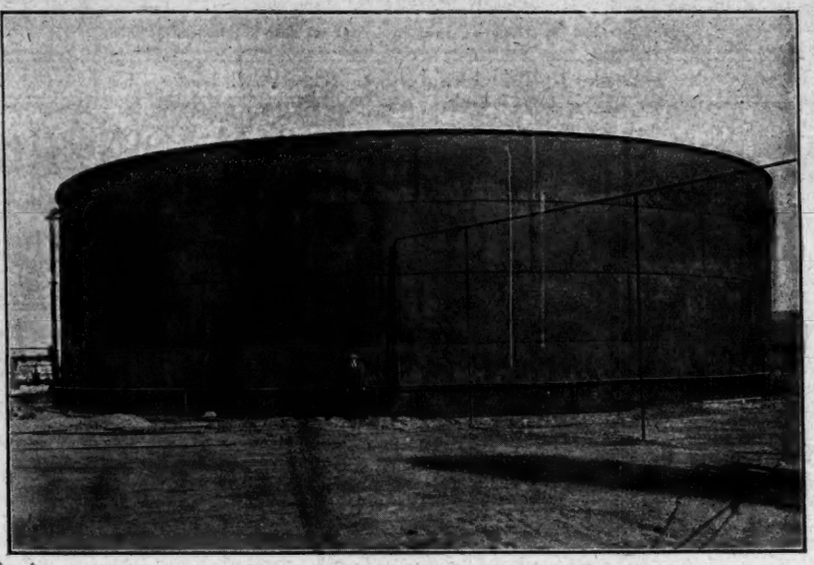

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VOL. CLVIII., No. 3085.] WEDNESDAY, JUNE 28, 1922. [74TH YEAR.

EDITORIAL NOTES.

Réunion of the Institution and the Société Technique.

THE meeting of the Institution of Gas Engineers last week, under the presidency of Mr. Thomas Hardie, is one upon which he and all who took part in it will ever look back with more than ordinary interest and with the happiest of recollections. The proceedings have on this occasion to be regarded from two angles; and what we see from either point of view makes us a little doubtful as to which angle is the more important. The points of view are the social side and the technical. Both were exceptional on this occasion—on the one hand because of the visit of the Société Technique, and on the other because of the first public exhibition and description by Prof. C. V. Boys, F.R.S., one of the Gas Referees, of the recording and integrating calorimeter of which he is the inventor, and which, it is quite possible, will play an important part in the making of the future history of the gas industry. In saying this, we are not inferring that the other contributions to the proceedings were not important and valuable. They were; but they are incremental to pre-existing knowledge, while Prof. Boys' invention contains novelty and (if use and experience confirm his belief) practical achievement in a direction in which a few months ago confidence was rudely shaken as to the possibility of realizing that which the industry very much wants as the complement to enable full compliance with the decrees of the Gas Regulation Act.

For a space, however, we will leave the technical proceedings, because the incidents of the week in connection with the visit of the President (M. R. Ellissen) and members of the Société Technique de l'Industrie du Gaz persist in somewhat monopolizing thoughts as a beginning is made with these comments. The fact is the evidence of deep impression. This is the first official visit of the French gas engineers to this country since the great, protracted, devastating war, of painful and yet glorious memories. While it shook the world to its very foundations, while the aftermath has been a great disturbance of the world's ways, nations have learnt to know each other better, and there is a large international desire, which is materializing in effort, to make common development in effecting progress, and in ensuring a lasting peace. In these circumstances, the coming of the President and some fifty members of the Société Technique is an event that is lifted out of the ordinary groove. Some of our visitors had themselves taken part in the titanic struggle shoulder to shoulder with our own kith and kin; and many of them had lost sons and other relatives in the cause which called for the mighty endeavour on the part of nations in the defence of right and freedom in the world. Alliance is cemented by reciprocal sympathy. The bonds of friendship are indissoluble; but about those bonds there is an indefinable something when applied to men engaged in common pursuits, as are the professional men of the gas industry. Apart from all else, there is a mutuality about the character and results of their work which draws and brings them together. The synthesis in such case passes beyond friendship into brotherhood; and that was the feeling pervading the lecture theatre in which the informal welcome of Wednesday evening was transformed into—not a formal, but a collective one of bodies of men with thoughts and aspirations in unison. The enthusiasm on both sides was genuine. It vibrated and moved, particularly when the fellow Presidents side by side dwelt upon the relationships in war, peace, and scientific work, and upon, in war, the terrible sacrifices that all had made. The unforgettable things have indeed caused a great solidification of the oneness with which the two nations, supported by others, faced the great tragedy.

Words permeated by sincerity tell; and such words supplemented by gracious and reverential acts sink well home. With full-hearted emotion our friends from France stood, in company with Sir Robert S. Gardiner, Mr. Thomas Goulden, and Mr. A. E. Broadberry, at the Cenotaph; and there M. Ellissen deposited a wreath—a token of great respect for those of our dead who rest in Continental soil, and of sympathy for this country and the relatives of those who lost their lives on the battlefields or on the seas. They visited the "Unknown Warrior's" tomb; and when at Beckton on Friday, there again the President deposited a wreath at the foot of the monument which has been erected to memorialize those valiant ones (formerly in the service of the Gas Light and Coke Company) who made the great sacrifice. These acts will abide with us; they are imperishable. The same feelings of oneness in relationships and the same heartfelt sentiments ran through the days of the visit—particularly at the luncheon given by the President and Council on Thursday, at that on Friday by the Governor (Mr. D. Milne Watson) and the Court of Directors of the Gas Light and Coke Company, when a visit was paid to Beckton by the members of the Institution and the Société Technique; and, again, at the dinner to which the visitors were invited by the Chairman (Mr. H. E. Jones) and Directors of the European Gas Company. But dining and speech-making, and acts of respect, were not the only objects of the visit. Our French *confrères* came also to see and to learn; and technical interests were aroused and brought into play by the visits on Thursday afternoon, arranged by the Chairman (Dr. Charles Carpenter) and his colleagues, to the East Greenwich works of the South Metropolitan Gas Company, by Sir George Beilby and his staff to H.M. Fuel Research Station, and by the visit already mentioned to vast Beckton, where a large amount of plant reconstruction has been proceeding during the past three years. And again diversity was provided by the highly delightful reception and dance on Thursday evening at the invitation of the President and Mrs. Hardie, who were thoroughly pleased with the enthusiastic manner in which their French guests joined in the sprightly lancers or waltzes, or the more stately measures. The visitors left our shores on Saturday for the Continent, with feelings of happiness and strengthened relationships and resolutions.

The meeting and the various functions were all a great success. Everybody was willing and anxious to rally round the President (his own Governor and Directors especially) in order to make them so. And this applies to the technical as well as to the social part of a programme which can only be described as excellent, and which was carried through with a precision which accorded well with prearrangement. We must here add our congratulations to Mr. J. D. Smith, of Belfast, upon his succession to the Presidential Chair of the Institution. He has been an excellent worker in the gas industry, and, under extreme difficulties, has served Belfast well. No better acknowledgment of this could have been made than by the attendance of the Lord Mayor of Belfast (Sir William Coates) heartily to invite the Institution to hold their annual meeting in Belfast next year, if events will permit. Mr. Smith has also been an unobtrusive but persistent and loyal worker in the Institution. Mr. James Paterson is now the junior to Mr. Samuel Tagg in the Vice-Presidency; and he will, when the time comes, as all his friends know well, maintain the prestige of the chief office with the dignity and ability that are associated with his patronymic.

The President on the Ways of Progress in Economy and Efficiency.

ONE can often forecast the characteristics of a Presidential Address if intimate knowledge is possessed of the man who is going to prepare and deliver it. Those who have knowledge of Mr. Hardie felt sure he would make a broad survey of those affairs that are of special current interest to the gas engineer, and that he would give of the deep reflections he has made upon them with a frankness of statement which no one can mistake for other than personal conviction. The components of the address had as their staple foundation the production of therms; and the various processes, or improvements of old processes, tried and offered, that have this objective were subjected to examination. The President had also much to say about coal and its influence upon the work of the industry. In its fortunes the price and the quality of coal are naturally both highly important factors.

Entrance upon the subject-matter of the address was made by referring to the subversive coal strike, which, after a three months' run, was ending about this time last year. Though in many ways that strike was a costly and destructive experience, it had certain good and prompt results, which, it is safe to say, would not have been realized except after the lapse of much time, and by fighting foot by foot of the way for the same final result. When gaily starting out on the strike, the miners had not looked forward and gauged the probable effects. They simply made a plunge, on being invited to do so by their imprudent leaders, into unknown ways for a political will-o'-the-wisp. By so doing, they gained practically no immediate advantage, but helped to produce conditions which prolonged their miseries beyond the duration of the stoppage which they themselves had brought about. Those conditions were economic in character, and against them no combination of men could stand. Before they laid down their picks and shovels, trade depression had set-in, and the export coal business was rapidly declining. If they and their leaders had not been so short-sighted, they would have seen that the conditions which were already here before the strike would inevitably be considerably worse at its end. Thus, in these circumstances, the latter condition of the men would be worse than the first. This is what actually happened. With trade depression, with quantities of coal in other countries sufficient for the then current needs, and much to spare for export to this country, work was resumed at our own pits with demand low; and the coal and coal-shipping industries found themselves—far different this from precedent—with a capacity much in excess of the satisfaction of needs. There could only be one trend to affairs in such circumstances—a gradual reduction of prices to stimulate demand and sales. This has resulted; and the President was able to say that since the beginning of this year the price of coal has been more in accord with the economic requirements of the world. So demand has steadily increased, and is still increasing. The price was a terrible one that had to be paid for freedom from intolerable conditions and ambitions; but the results have proved of incalculable benefit to the industries of the country. At the same time, the President warns us against hoping that pre-war prices for coal will again be reached. Prices to the consumer have now to bear the dead weight of the shorter shift that is now worked in the mines.

There are inter-relations in these matters. Capital cannot do without labour; nor can labour do without capital. Coal and the productions of industry cannot do without railways and other means of transport; and the means of transport cannot live without the conveyance and use of coal and the goods produced by the various industries. There is too little thought given to this fact of inter-relation, with the result that there is a great deal too much selfishness abroad. The trade unions have inscribed on their banners "A higher standard of living." That is quite good, and no one objects. But they want the higher standard of living to be theirs through higher rates of wages, no matter whether or not those rates are beyond what is economically permissible. This will not do. When in costs we get beyond the economic limits, then we are handicapping ourselves in trade competition. As the President points out, the standard of living must be improved, and can only be universally improved, by greater production and the cheapening of commodities. All through the address we see the view that advances in economy and efficiency—efficiency of plant, processes, and men—are the only ways by which there can be healthy achievement in this regard, and progress be made, and ambitions gratified. Trade unionism has adopted other means, which are only the product of visionaries, and have no fundamental support, and so must fall. The higher standard of living with them should be realized by raising the rates of wages, by shortening the hours of work, and by the exercise of the corrupt policy of "ca' canny." The mischievous teachings of the labour doctrinaires require to be countered, and countered by something sound, which will create confidence and mutual assistance as between employer and employed. And the President finds nothing better on offer than co-partnership. It is the best educative plan that has yet been devised; and it is the best solution of the problem of how to bring what superficially have been opposing interests, but are inherently mutual interests, into perfect and natural harmony. Co-partnership stimulates the interest of the employees in the financial side of an industry, as well as in the questions of management; and this brings to the minds of the men a greater knowledge of the difficulties (of which they have hitherto known so little) of their employers. That inter-relation of interests, as has been said, extends from industry to industry. Transport enters largely into the requirements of the gas industry. The President hopes to see railway rates brought down so that materials may be delivered more cheaply; but he does not want this to happen by reducing below a reasonable level the wages of the railwaymen. He believes that the reorganization of our railway systems, and the seeking of economies and higher efficiencies in ways which he specifies, will bring about the result. In every direction, economies and better efficiencies are more necessary to-day than ever.

In several ways conditions have arisen that are obstructive to the progress realized through greater economy and efficiency. The President gives us a decisive apothegm when he says: "The quality of coal is no less important "than price." That is true, because the damage produced by bad coal has no definite bounds. There is regret on the President's part that there has not been greater improvement in the amount of inerts in coal, which are accountable for much uneconomy and inefficiency. The quantity of inerts in coal was ascending before the war; and therefore the President holds, and properly, that the users now have a right to claim that something less than the pre-war quantity is necessary. It may be that the coal available to-day is more difficult to clean; but unless collieries can supply coal containing less inert material, gas undertakings themselves will, the President believes, have to add to their already numerous processes one for coal cleaning. This is not a particularly nice outlook. But the advantages of higher plant efficiency, better productions of gas and secondary products, and higher quality of coke might even justify that expense. This brought the President to assert that while proximate analysis is an important guide to the value of coals, provided the samples analyzed are fairly representative, such analysis should only be used in conjunction with carbonizing tests when it is desired to determine the relative value of coals from different collieries. There will be agreement with this. The investigations at the Fuel Research Station, however, show that, for the realization of the highest results, it is necessary not only to know the relative value of coals from different collieries, but from the different bands constituting seams of coal, owing to the considerable differences in fusibility and infusibility, which play an important part in the structure of coke. Dr. Weyman has shown, too, how different are the rates of gasification of coals even from the same coal-fields. Coal which gives off its volatile matter at low temperature will require the expenditure of less fuel; and it has the advantage of easier production of the maximum quantity of gas. There is no question that the more the gas industry knows about coals, the better; seeing the great bearing that their chemical and physical characteristics have upon efficiency in production and upon the quality of the commodities yielded. Moreover, the variety of carbonization and gasification processes that are in existence to-day enable treatment of a greater variety of coals; and so it will be a good thing to have more exact knowledge as to what is required by those processes individually in the way of raw material for the attainment of the best results.

The President takes a broad view of the potentiality that the Gas Regulation Act confers upon the industry. The freedom of choice of a standard of calorific power must,

in his opinion, eventually evolve the means of producing gas of a new composition and under novel conditions. In this we agree with him; and here we begin to meet with the President's deep thinking over new processes that are proffered for acceptance, and with the caution which is his personal trait. He takes nothing on face value or on the excellence attributed to processes by their authors or by their makers. He first warns against instituting declarations of calorific power other than upon the capabilities of the plant actually in being at the time, and the conditions in respect of coal and other matters that are current. He speaks, too, of the difficulty of breaking-off the old habit of gauging things by the cubic foot, and of adopting the therm in its stead. But it has got to come; and then the present complexity will give way to the simplicity that the therm presents. He is satisfied that the system of charging by thermal value is that by which the consumer will obtain the greatest satisfaction. As to thinking in therms instead of cubic feet, the President will find illustration of the value of this in our review of "Field's Analysis," as published in the "JOURNAL" last week.

Coming to the new processes of gas production, the survey that Mr. Hardie made of them was listened to with considerable interest; and there was nothing of a cursory nature about what he had to say. He finds that the change in the method of charging for gas has added to the advantages of water-gas plants, as they enable a wider control to be maintained over current conditions in respect of the values of coal, oil, gas, and coke and other secondary products. That is an important advantage. What the ultimate position of total gasification may be, he does not say. But such processes must be looked at from the current standpoint; and the charges involved by change must be taken into the reckoning of relative benefits or otherwise. In his view, complete gasification processes cannot be contemplated for the replacement of existing plant, unless they are prepared to bear the burden of charges on the capital they displace. For meeting new consumption, they may be carefully considered; but there must not be oversight at the cost of distributing the lower qualities of gas. There is evidence that the President is not at all satisfied with the information so far given as to these processes; and he wants more, and of a positively reliable character. His leaning in total gasification is towards internal heating, which enables gas to be produced without overloading it with inerts, though with caking coal means must be adopted to prevent any stoppage of the freeway for the heating gas and products. This is where the lessons from the Fuel Research Station come in usefully in respect of the investigations into the conditions affecting coke structure; and the advantages of mixing coals of high fusibility with coals that tend to infusibility. As to the use of oxygen in carbonization, again the President's caution and penetration give rise to some doubt on the financial side. He makes an estimate based on the Jefferies-Norton system, and the calculations by Prof. Cobb and Mr. H. J. Hodsman. And he says: "On "the assumption of 243 therms per ton, the estimated cost "of production would give a cost per therm of 2·3d. In "my opinion, the advantages should be more definite and "greater before an undertaking would be justified in em-"barking on such a scheme at an expenditure of £100,000" —that is, for oxygen plant alone, with an output of 3 millions a day. He is not by any means convinced as to the oxygen gas-producing system turning-out to be all that is expected of it by its advocates. But even the biggest doubters in other matters have become converted by practical experience. The President suggests that experiments should be made to ascertain what will actually occur in a producer if only oxygen diluted with steam were used. Probably the conditions would be quite different from those anticipated, and the estimated results would require considerable modification. The high percentage of carbon monoxide might be a debarring factor for the use of the gas in domestic operations. Reference is also made to coal briquetting, and subsequent carbonization in bulk—this being the process proposed by Messrs. Sutcliffe and Evans. It is regarded by the President as possessing great possibilities, in which gas coke in varying proportions and of good quality "might" be produced. There is not much encouragement given by him to the utilization as an enricher of gas from low-temperature carbonization, owing to the financial doubts that surround the other products of the process. There is also a critical survey from the financial side of the utilization of coke-oven gas. The President is not opposed to this; but the tendency of his criticism is that the price of the coke-oven gas must be such that to it can be added several items of charge—particularly in respect of the maintenance of displaced or stand-by plant—in order to justify the use of the gas on economic grounds for town supply. All the President had to say with respect to refractory materials, the chemical control of the operations of a gas undertaking, and the value of the lighting load, are so much in accord with accepted views that comment upon them is unnecessary.

From every part of the industry there will come endorsement of the high note upon which the address concluded, when the President said: "We in the gas industry, with "knowledge of its capabilities and possibilities, have never "been so sanguine of success, and have never felt so confi-"dent that our business will continue to flourish." Those are the views of all sentient men in the industry. The capabilities and possibilities of the work of the industry have not yet presented us with any definite bounds. Fresh extensions are constantly coming into our view; and therefore our convictions as to greater successes are on safe ground.

Technical Reports and Papers.

THE technical reports and papers presented on this occasion were of a diversified character. Owing to the number of subjects, extended comment cannot be made to-day. But this can be said, that through them knowledge appertaining to gas production, testing, and utilization has been enlarged, though it cannot be said that any of them—save perhaps that of Prof. Boys—is of an epoch-making character. The contribution of Prof. Boys was the last on the programme. It is the first in importance to the gas industry at the present time. As matters stood when the Institution met last autumn, there was considerable doubt as to whether a recording calorimeter would ever be forthcoming that would be sufficiently dependable in all circumstances to perform the precise functions imposed upon an instrument of the kind by the Gas Regulation Act. Investigation had shown that a recording calorimeter is exposed to so many accuracy-opposing conditions that it seemed next to impossible that they could all be surmounted, and under all conditions an exactitude assured that would give a fairly full measure of confidence. But there is greater confidence to-day, after hearing the account by Prof. Boys of the devising work that he was then patiently and experimentally engaged upon, guided by his knowledge of chemistry, physics, and, calorimetry. The result of that work was before the members in an instrument as produced by the makers. Prof. Boys appears to be perfectly satisfied with the new instrument, through his long experience with it, during which he has effected many improvements. All in a position to judge acknowledge the skill and ingenuity that has been brought to bear in designing the components, in the selection of materials, in the application of the integrating device and, in short, in producing the finished instrument. It is also conceded that scientific knowledge has brought forth something that is simple, and that should not be inordinately expensive—as such things go. At the same time, there will be a general desire to see the results of the operation of the calorimeter away from its skilled inventor and master, and in the variable circumstances of different gas-supply areas. To mention only one point, Prof. Boys has adopted the principle of a water-flow calorimeter; but he has had no experience of acid water or peaty water. In view of the importance of the subject, the complete paper will be read with close interest. Its structural features will be critically examined by other designers and manufacturers; but in making criticisms, it will be well to remember that Prof. Boys has spent two years upon this work, and, as one critic found at the meeting, he has a ready answer for any fair criticism on detail. For the present, we will leave reference to the new instrument at that, with only the further remark that a positive recording calorimeter, under the conditions of use in which Prof. Boys has been working, is not to-day a hopeless proposition, but is (on his authority) an accomplished fact.

The structural engineering matter before the members was not extensive. But it had good representation in the paper read by Mr. W. B. Leech, Engineer of the Beckton Station of the Gas Light and Coke Company. There has been a busy time lately at Beckton; and the author of the paper had so much to write about, that he had to confine

himself to a mere outline of what has been done. Interpolated in the structural details he gave are reasons for choice of types of plant, and some interesting notes as to experiences. But in reading the paper one must throughout take into account that this is Beckton; for it will be seen that the original lay-out and design of the buildings and plant, the extent of operations, and the fact that several varieties of Durham coal have to be used, impose limitations on the types of plant employed—especially in the retort-houses. If Mr. Leech was dealing with other conditions, there is no doubt that he might favour some other forms of plant. Because one works takes a certain course to-day, it does not follow that that course would be the best for all other works. Speaking of carbonization, Dr. Weyman's paper is both interesting and valuable as a study of the effect of the rate of carbonization on the increase of production. This is very much a matter of temperature, retort system, and physical characteristics of coal. One cannot generalize in this matter; and therefore Dr. Weyman's findings must apply to the particular conditions under which his tests were carried out. The rate of heat transmission through refractory material has a bearing upon this matter; and quality and suitability of material is therefore important. The report of the Refractory Materials Committee, which was presented by Mr. A. E. Broadberry is instructive in this respect. It is not altogether so satisfactory as we should have liked to see it. Reading between the lines, we fancy Mr. Broadberry is not altogether pleased with the pace at which the work has been proceeding. The investigation, it will be remembered, was, on financial grounds, absorbed by the British Refractories Research Association; but we rather fear from the appearance of things that the work of the gas industry is being treated more or less as a side issue. We hope this is not actually so; and that the slowness of pace is due to lack of financial support, which in itself is wrong. Mr. Broadberry complains of this. Certainly it is a reflection on the industries using refractories if they cannot see that, costly as maintenance is in the matter of refractory materials, it is to their advantage to spend money in trying to effect improvements in quality to get products that will withstand the severities of temperature and work to which they are exposed in different processes. One thing the report presented on this occasion teaches is that experimental work and practical use must be both considered before specifying anything, and that the experimental work should be made to represent working conditions as nearly as possible. The specifications applying to refractory material in the gas industry, it is found, require some modification, and this is a matter that is now in hand. However, through private generosity, it is expected that investigation will, at any rate for a few years, be carried on at greater speed, and with better result.

The seventh report submitted by the Research Sub-Committee of the Gas Investigation Committee treats of the thorough inquiry that Dr. Parker has been making into carburetted water-gas plant, with a waste-heat boiler. This is largely a thermal inquiry to determine under a defined set of conditions the thermal efficiency of each part of the process. It is very necessary in work in this quarter to know the calorific power of the carburetted water gas produced, as overall efficiency is much influenced by the amount of oil gas mixed with the water gas. The oil part of the process, its thermal efficiency being high, has a substantial effect upon the whole thermal efficiency. Hence the need for the information; and hence, too, a reason why the ascertained efficiency for the plant at Birmingham upon which the tests were made may not apply to other plants. However, in this case, when steam was raised in outside boilers, the overall efficiency of the whole process was 59·5 p.ct.; but with waste-heat boilers, it was 68 p.ct. Therefore, by the use of waste-heat boilers, the efficiency was increased by 8·5; but the total heat of the steam raised in the different tests was only from 41·9 to 49·6 of the heat entering the waste-heat boiler. This is poor; and the makers of waste-heat boilers should note the suggestion of the Committee that the low efficiency might be improved by more satisfactory means for burning the combustion gases leaving the superheaters during the blow periods, which would enable the production of a larger quantity of steam. Dr. A. C. Monkhouse is the holder of the Institution Research Fellowship; and he and Prof. Cobb made a further report on the subject of the liberation of nitrogen and sulphur from coal and coke. The maximum liberation of the nitrogen is with steam; but steam has also a tendency to let loose the sulphur more vigorously, which means more work for the purifiers.

Coming to gas utilization, the Gas Investigation Committee have also been at work, with Mr. James W. Wood as Research Chemist, on the aeration of atmospheric flames. There is no doubt there is a lot of theoretical or hypothetical belief as to what happens under different conditions in this matter of flame aeration. It seems very probable that the investigation as it develops will knock on the head many of the opinions that have had continued existence because there has been no reliable experimental evidence to controvert them. So far, it appears as though this evidence will be forthcoming; and it will be very welcome. The research is in hand; but the data are not yet in a finished state. It is hoped, however, that they will be ready for the next annual meeting.

We have, in this comment, been classifying as near as possible the subject-matter treated upon in the papers. In doing this, unfortunately, the important contribution to the proceedings by Dr. Carpenter has fallen for notice nearly at the end. The paper is a strong plea for more work to be done in retaining and further improving the lighting load. Dr. Carpenter in such matters as this may have high ideals; but he has no desire whatever to force them upon other gas administrators What, in effect, he says is: "These are our views and our practices. What have "you to say to them?" The paper that he read was on "Some Gas-Burners, and a Moral." There was a charge of neglect in it; and it is this neglect that is causing some depression, greater or less in different areas, in the lighting curve. This neglect also leads to the purchase and employment of shoddy burners and fittings; and even the showrooms of some gas suppliers are disgraced by them. Gas men know very well this is not right; and it was freely admitted during the discussion. Then he pleaded for a high standard of design and finish of gas-fittings. Is he right or wrong in this? Nobody said he was wrong; all agreed that he is right. Again, he urged the standardization of burners and their accessories; and nobody quarrelled with this. So far so good. The author came to fixed gas and air adjustments; and he admitted that this means more or less standard gas. It was argued that this could not be realized in many gas-supply districts; and there the objectors are right. The ability to regulate the gas and air is an economic necessity in not a few areas. But if it is accepted that Dr. Carpenter is right, and if the ideal of a standard gas can be achieved, then it would be as well to find out what is the nature of the divergence from it that is permissible with fixed gas and air adjustments. Some gas engineers appear to think that Dr. Carpenter is so precise about standard gas that it must not move a hair space from the declared datum-line. This is a wrong conclusion. In his paper we read that long experience has shown that burners without gas and air adjustment other than is provided by the tap can be designed which will afford an efficiency deviating but little from the pre-determined value, provided the calorific value of the gas does not depart from the declared standard by more than 25 B.Th.U. This is a statement that should be widely considered in connection with this question of standard gas. Dr. Carpenter particularly called attention to two curves which are reproduced with the paper, and which he says point a moral. He suggests that all gas men should study these curves, and see what lessons they can derive from them.

Finally, there is the report of the Joint Committee on the Life of Gas-Meters, which was presented by Mr. R. B. Parkinson and Mr. J. G. Taplay. The report will be found particularly useful; for there is in the opening a summary relating to the malignant impurities in gas which attack metal and other materials; and the remedies and palliatives are pointed out. Regarding the removal of hydrocyanic acid, the chalk process has proved a success. It has been patented by Mr. Taplay and the Gas Light and Coke Company; and permission to make use of it can be obtained by application to the Secretary of the Company. For this work, the gas industry are much indebted to the Company and to Mr. Taplay. The mischief that hydrocyanic acid is doing is incapable of estimation. The process, on the other hand, is a cheap method of getting rid of a very undesirable constituent of gas.

From the technical point of view, the annual meeting has added considerably to the stock of information on many subjects of value to the gas engineer and the chemist.

National Gas Council and the Gas Regulation Act.

THE pressure of last week's doings in London prevents any full editorial notice of the proceedings at the meeting of the National Gas Council, which is reported in later columns in this issue. The President (Mr. D. Milne Watson) had many topics upon which to touch and to inform the members. It will be a satisfaction to them to know that the roll of membership has been extended by the incoming of 49 additional gas undertakings. This gives the Council a membership of 877 undertakings, representing between 90 and 95 p.ct. of the gas made in the United Kingdom. There has never been a body in the gas industry that could be said to represent through its membership the industry with such completeness as this. As the President said, it can claim to be a truly representative body. An important announcement had reference to the issue of Orders under the Gas Regulation Act. Last year there were many difficulties confronting, and which could not be dealt with in any off-hand manner. But as time passed, the Director of Gas Administration (Mr. H. C. Honey) was able to speed-up the rate of progress. Therefore the President was in a position to announce that by the beginning of the present month 250 Orders had been issued; and he believes that every case in which severe hardship was being experienced has now been dealt with. This is highly satisfactory. It is remarked, from a statement on the same occasion by Ald. F. S. Phillips, that there is to be a conference of municipal corporations to consider their position under the Act. The case of local authorities, he submits, is different from that of companies; and therefore they wish to determine their attitude in relation to the Act.

Stretford Price to Cover Expenses.

The Bill constituting a Joint Board for taking over from the Manchester Corporation the Stretford gas undertaking, has been passed by Sir Henry Samuel's Committee. This was done subject to a clause providing that the price charged for gas should be such as to cover expenses, so as to avoid a rate-in-aid. This was a point that the Manchester Ship Canal Company (for whom Mr. Arthur Valon was acting) put forward. They are not consumers, but large ratepayers; and the only ground for their opposition could be that there was a possibility of a rate-in-aid. Their case was that a pledge had been given that the Board would supply gas on the same terms and at the same price as Manchester, and that, this being doubtful, the probability was that there would be a rate-in-aid. In neither House would the Committee consider the question as to which was the best proposition—Manchester or Stretford—from the point of view of the supply of gas in the area. The real difficulty in the way was that there was no opposition from gas consumers in the Gas Board area; the big consumers probably being afraid that it was the thin end of the wedge to get the area included in the Manchester limits.

PERSONAL.

Mrs. WALTER KING asks us to acknowledge through the "JOURNAL" columns her grateful thanks for the many kind expressions of sympathy she and her family have received during the past week from members of all branches of work in the gas industry. The widely-expressed esteem in which Mr. King was held is to her and the family a great consolation in their grief.

The Council of the University of Leeds have appointed Dr. W. T. DAVID, M.A. Cambridge, D.Sc. Wales, to be Professor of Civil and Mechanical Engineering, and to take up his duties next October on Prof. Goodman's retirement from the Chair. Dr. David is at present Professor of Engineering at the University College of South Wales, and was educated at University College, Cardiff, and Trinity College, Cambridge. He served as Demonstrator in Engineering under Prof. Bertram Hopkinson at Cambridge for two years, and acted as Assistant Gas-Engine Designer at Messrs. Mather and Plat's, Ltd., for one year, after which he was appointed H.M. Inspector of Technical Colleges under the Board of Education. In his research work he has specialized on internal combustion engines, and has contributed a number of papers to the Royal Society and to the scientific periodicals.

Lowest Therm Price.—We believe that the Coatbridge Gas Company (the Engineer of which is Mr. George Braidwood) is to-day supplying gas at the lowest price on the therm basis in Scotland. The figure is 8·4d. per therm. All the gas is made by Glover-West vertical retorts.

THE LATE MR. WALTER KING.

DURING the past week, several public references have been made, at the meetings in London, to the death of Mr. Walter King, the late proprietor of the "JOURNAL," and the (until illness laid him aside) director of the work that did so much for the advancement of the interests of the gas industry. Tributes of regard and of testimony to his life's work have also been made personally and by post—the numerical character of which is only transcended by the depth of the universal sympathy with the family and the "JOURNAL" staff, and the sincere expressions of respect for Mr. King and of appreciation of his personal qualities.

So numerous are the communications received that correspondents are asked to accept this general acknowledgment as genuinely earnest and an individual one. The letters received are from all parts of the country, from abroad, and from men in different spheres of work in and associated with the gas industry.

This spontaneous and universal testimony makes a personal appeal to the writer. Two courses are open to him—to let this acknowledgment stand without extension, or to publish some of the communications which have been received. Could the writer, as he often did through long years of responsible association, consult his late chief, he would say, the matter being personal to himself: "Enough has been said." But the writer has to determine; and his feeling is that now and here he should place on record, at the end of a life well spent in the interests of the industry, some of the appreciations of work and of the expressions of personal regard.—A. F. B.

APPRECIATIONS.

Mr. D. MILNE WATSON,

President of the National Gas Council, and Governor of the Gas Light and Coke Company.

I was very sorry to hear of Mr. King's death. His loss will be a great one to the industry; for there were few that knew more of it from the inside than Mr. King did, and he was always a very good influence in its affairs. I shall miss his cheerful presence at our various meetings. I am sure all of us feel we have lost a personal friend; and I am sure the sympathy of everyone will go out to you and to the members of his family at this sad time.

Dr. CHARLES CARPENTER,

President of the Gas Companies' Protection Association and of the South Metropolitan Gas Company.

I am very grieved at the news to-day. Mr. King was not only outstanding as a journalist, but he was a tower of strength to the industry, which will greatly miss his valuable advice and clear-seeing judgment.

Mr. THOMAS HARDIE,

President of the Institution of Gas Engineers.

I am very sorry indeed to hear of the death of Mr. King. I beg to offer to all concerned my sincere condolences in their great loss.

Sir GEORGE BEILBY, F.R.S.,

Director of Fuel Research.

I have learned of the illness and the passing away of Mr. King with the deepest regret. It has been my privilege to be in touch with him, and with his public work, for more than forty years; and I have been deeply impressed, not only by the width of his knowledge and his grasp of technical questions, but even more by the high standard of intellectual honesty which has characterized his work as a publicist. May I offer to you and the family my deep and most respectful sympathy in the sad loss you have sustained.

Prof. ARTHUR SMITHELLS, F.R.S.

I should like to be allowed to offer an expression of sympathy with all concerned in the "GAS JOURNAL" on the death of Mr. Walter King.

It is not necessary for me to attempt to estimate the services which he rendered to the gas industry and to the public by his conduct of the "JOURNAL." They will, I am sure, be acclaimed on every side. But as one who has been concerned with science and education, and has been anxious to see the establishment of harmonious co-operation between the scientific and industrial worlds, I can bear the testimony of long and intimate experience to the great part Mr. King has played in promoting this good cause. Under his inspiration, the "JOURNAL" has stood steadfastly by it, and has exercised a most fair and useful moderating influence. He was equally patient with the extremists of either side, and was assiduous in promoting a good understanding.

In all relating to this University, in the foundation of the Livesey Chair, in the promotion of joint-research, and in development of professional education, Mr. King rendered invaluable service. The University is, I am sure, under a deep debt to him; and personally I mourn the loss of a good friend, whose sympathy and help have for long years been always freely given.

Prof. Cobb wishes to associate himself with all I have said in this imperfect acknowledgment of our debt to Mr. King.

Prof. WILLIAM A. BONE, F.R.S.

I was exceedingly sorry to learn, on opening my "JOURNAL" this morning, of the sad loss which it and all of us have sustained in the death of Mr. Walter King; and I wish to assure both your staff and his family of my deep and heartfelt sympathy.

It is fifteen years or more since I first made Mr. King's personal

acquaintance; and, although we may have at times held different opinions on matters relating to the gas industry, I have always entertained towards him feelings of the highest respect and personal friendship. He has always extended to me, in my many dealings with him, unfailing courtesy and kindness; and I have always felt that the few differences of opinion which we have had during those years have deepened our mutual esteem and goodwill. His death, therefore, comes to me as a great personal loss; and I should be glad if you would kindly accept and convey to his family this expression of my sympathy and appreciation of his friendship and worth.

MR. JAMES W. HELPS.

How terribly grieved I was to see from this week's "JOURNAL" that my old friend, Walter King, had passed away. I had no idea he was so seriously ill. No one knew him and his generous nature better than you did. I most sincerely sympathize with you and the staff of the "GAS JOURNAL."

Mr. F. H. JAMES,

Secretary of the Imperial Continental Gas Association.

It is with very great regret that we learn of the death of Mr. Walter King. Not merely are we conscious of the invaluable service which he has rendered to the gas industry as a whole; but we also treasure the memories of the many cordial links which existed between him and this Association. Will you please convey to his family our deepest sympathy with them in their loss.

Mr. A. F. P. HAYMAN,

Engineer and Manager of the Antwerp Station, Imperial Continental Gas Association.

I have read with great regret the announcement in this week's "GAS JOURNAL" of the death of your esteemed Chairman, Mr. Walter King. Please accept my sincerest sympathy for you and your staff on the great loss you have sustained.

I have known Mr. King for many years, and have always held him in high regard; and I consider his death a very great loss for the gas industry in general. I can well understand how much he will be missed by you and all who knew him personally.

Mr. EDWIN UPTON,

Liverpool Gas Company.

The announcement of the death of Mr. Walter King will, I am sure, be received with universal sorrow throughout the gas industry. To me it came as a great shock, and caused extreme regret, yet I am glad his end was unattended by physical suffering.

Those who knew him personally are able to appreciate his generous nature, but we are all conscious of his strong, productive work, and one cannot help feeling that we were prone to accept the result of his labour too much as part of our daily life, for he had great qualities, and used them unselfishly for the advancement of the industry he loved, and which he served faithfully for more than half a century.

You will doubtless receive many spontaneous expressions of appreciation; and I would like to include mine. With him enthusiasm never waned; encouragement was not only kindly, but always well-timed; in criticism he was never unfair; he abhorred injustice; and a rebuke from him was never hurting—indeed, his record is an inspiration to each one of us.

It is very true that difficulties in the gas industry are probably greater than in any other industry, and certainly its problems are more complex and elusive; but Walter King had the gift of insight, and the whole industry is the better for it.

We are indebted to him for assistance, enlightenment—aye, and guidance; and reflection on his work will unfold lasting qualities.

If you will please accept my condolence, and convey very sincere sympathy to the bereaved members of his family, I shall be grateful.

Mr. N. H. HUMPHRYS.

I am deeply grieved on reading the first paragraph in the "JOURNAL" to-day announcing the decease of one of the best and oldest friends I have met in the gas profession; and respectfully tender sincere sympathy and condolences to the widow, the family, and yourselves in the irreparable loss you have sustained.

Mr. EDWARD A. HARMAN.

I am shocked to see the announcement in the papers of the decease of Mr. Walter King. He will be greatly missed by all who knew him, and particularly by those who knew him best. He was a true friend, and a perfect gentleman. I know your own personal feeling will be like mine—a very sad one. How we all shall miss him!

Mr. J. C. BELTON.

To say that I was shocked on opening my "JOURNAL" this morning does not convey the instant sense of grief and loss which overwhelmed me, as I read that Mr. King had passed away. I have known him nearly thirty years, and acquaintance has through all that time been always deepening into profound regard and sincere friendship. How strong the bond had become I only knew when I realized to-day that I should never again hear that cheery greeting, and feel the grip of that brotherly hand, which was always my welcome at Bolt Court. His was indeed "A heart of gold;" "to know him was to love." My sincere sympathy goes out to those he leaves behind, and whose loss transcends our own.

Mr. HUBERT POOLEY.

It is with extreme sorrow that I read of the death of Mr. Walter King; and I shall be pleased if you will kindly convey to the members of his family, and accept for yourself, my sincere sympathy. One of the best known men in the gas world, Mr. King always held my greatest regard and fullest confidence, and his loss will be greatly felt among us.

Mr. W. J. SANDEMAN.

I do not know any of the late Mr. Walter King's family sufficiently well to write direct, so am going to ask you to convey to them my sincere sympathy.

The gas industry has lost one of the straightest and most honourable of friends; and I personally feel I have lost a good friend, and one who has helped me on many occasions. He will be sadly missed by many outside his own family circle.

ALDERMAN GEORGE CLARK.

Chairman of the Society of British Gas Industries.

The writer was at the Institution meeting on Thursday, and heard with very deep regret that Mr. Walter King had passed away. We feel that he will be sadly missed in the gas industry, for he had created a great position for himself in all work connected with the industry. Will you kindly convey to his family, and accept yourself, this expression of sympathy and regret?

Mr. ARTHUR L. GRIFFITH,

Society of British Gas Industries.

I was very sorry indeed to hear that Mr. Walter King had passed away on Sunday. Please accept yourself, and convey to your colleagues, my sincere sympathy in the great loss you have sustained. I am sure he will be very much missed by you all, and by his many friends in the gas industry. He always took such a great interest in our Society, and was so helpful in many ways. I feel we have indeed lost a good friend.

Messrs. SAMUEL CUTLER & SONS, LTD.

We note with the greatest regret that your Chairman, Mr. Walter King, has passed away, and beg to offer our sincere condolences to his family and colleagues upon their irreparable loss.

As manufacturers whose association with the gas industry dates back to times even anterior to your late Chairman's long record of fifty-four years, we reflect with great pleasure upon the many instances when the sympathetic views, sound judgment, and well-informed criticism of the "JOURNAL" has placed both manufacturers and gas companies under enduring obligation to its able editorship. We greatly honour the memory of one who conducted the affairs of the "JOURNAL" with such ability and impartiality.

Messrs. CLAYTON, SON, & CO., LTD.

We have to offer the sincere sympathy of our Directors and staff in the great loss you have sustained by the death of your Chairman, Mr. Walter King, whose name has been so long connected with the "GAS JOURNAL" and the general progress of the gas industry.

Mr. W. R. GLOVER (Thomas Glover & Co., Ltd.).

It was with deep regret that we heard of the great loss your firm and the gas industry have sustained in the death of Mr. Walter King. On behalf of my firm, I beg to send our sincere sympathy to his colleagues, and to the members of his family.

These are samples of the letters received from all quarters during the past week. We sincerely thank, on behalf of Mrs. King and her family and the "JOURNAL" staff, all correspondents—named and unnamed—for their sympathy and kind expressions of regard.

FIVE PORTRAITS.

We reproduce herewith the photographs of the President of the Institution of Gas Engineers (Mr. Thomas Hardie, M.Inst.C.E.), and of the President of the Société Technique de l'Industrie du Gaz en France (M. R. Ellissen), the Vice-Presidents of the Société—MM. L. Rolland D'Estape, R. Masse, and G. Vautier.

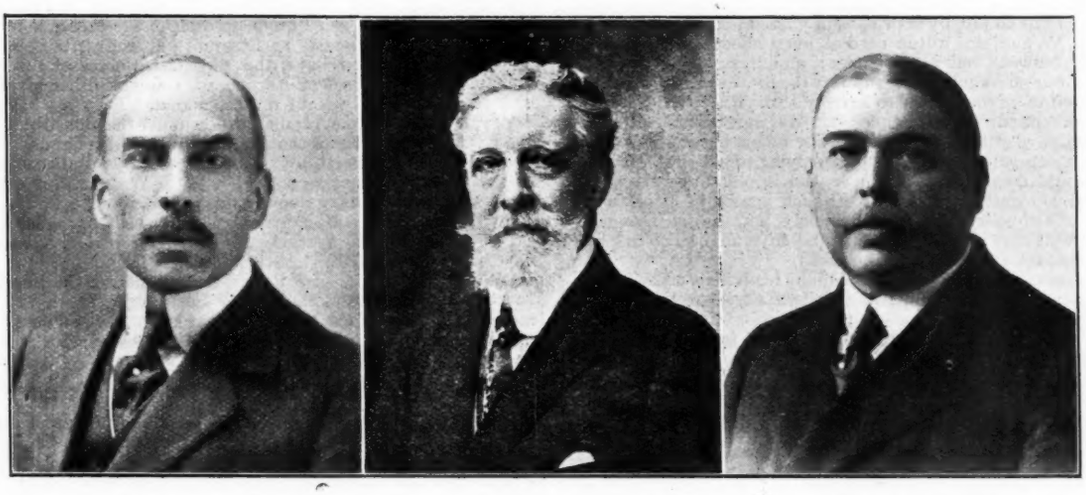
MR. THOMAS HARDIE,

The President of the Institution of Gas Engineers, served his apprenticeship with Messrs. John Abbot & Co., Ltd., Gateshead, General Engineers, having previously spent two years at the Durham College of Science. There he obtained the title of Associate of Science of the Durham University. Then for a short period he acted as Assistant to his brother, the late Mr. William Hardie, who was Engineer of the Tyneside Gas Company. In 1896, Mr. Hardie was appointed Assistant Manager at the Redheugh Works of the Newcastle and Gateshead Gas Company, at which time Mr. V. Wyatt of London was Consulting Engineer. In 1899, he was appointed Engineer at the Redheugh Works, by which time Mr. W. Doig Gibb had become Chief Engineer to the Company. On the latter's removing from Newcastle to London in 1909 to take up the position of Chief Engineer to the South Metropolitan Gas Company, Mr. Hardie was appointed to fill the vacancy at Newcastle. He was the President of the North of England Gas Managers' Association in 1906. For some time after its formation, he was the Vice-Chairman of the Federation of Gas Employers, Chairman of the Northern District Committee and Chairman of the Northern Regional Gas Industrial Council. In 1920 he was offered a position with the Gas Light and Coke Company; and on Jan. 1, 1921, he entered upon the duties of Deputy Chief Engineer and Engineer of the Bromley Station of that Company. On the retirement of Mr. T. Goulden, in January last, he was appointed Chief Engineer to the Gas Light and Coke Company.

[*Photo. by Bacon, Bond St., W.*

MR. THOMAS HARDIE,
President of the Institution of Gas Engineers.

M. R. ELLISSEN,
President of the Société Technique de l'Industrie du Gaz en France.



M. L. ROLLAND D'ESTAPE, M. R. MASSE, M. G. VAUTIER,
Vice-Presidents of the Société Technique.

M. R. ELLISSEN,

President of the Société Technique de l'Industrie du Gaz en France, Administrateur-Délégué de la Compagnie Générale du Gaz pour la France et l'Etranger, Administrateur de la Société du Gaz de Paris, de la Compagnie du Gaz de Mulhouse, de la Société Italienne du Gaz. Chevalier de la Légion d'Honneur—Croix de Guerre.

M. L. ROLLAND D'ESTAPE,

Vice-President of the Société Technique de l'Industrie du Gaz en France, Administrateur-Délégué de la Société du Gaz & de l'Electricité de Marseille, Administrateur de la Société du Gaz de Paris, Président du Syndicat Professionnel de l'Industrie du Gaz. Chevalier de la Légion d'Honneur—Croix de Guerre.

M. R. MASSE,

Vice-President of the Société Technique de l'Industrie du Gaz en France, Vice-Président Directeur de la Société d'Eclairage, Chauffage et Force Motrice, Ancien Président du Syndicat Professionnel de l'Industrie du Gaz. Officier de la Légion d'Honneur.

M. G. VAUTIER,

Vice-President of the Société Technique de l'Industrie du Gaz en France, Administrateur-Délégué des Compagnies de Gaz and d'Electricité réunies, à Lyon.

DINNER TO THE FRENCH VISITORS BY THE EUROPEAN GAS COMPANY.

A FITTING finish to the social events associated with the visit of the President and members of the Société Technique de l'Industrie du Gaz was given by the Chairman (Mr. H. E. Jones) and his colleagues of the Board of the European Gas Company. They invited all the visitors to dine with them on Friday evening at the Savoy Hotel; and all accepted with appreciation. Everything was done in that tasteful style which adds charm to such an occasion. Mr. Jones, full of vivacity and courtesy as ever, welcomed heartily the many guests, among whom were a few English friends, some of them well known to the visitors. There were present: Sir R. S. Gardiner, Sir C. R. S. Kirkpatrick, and Messrs. D. Milne Watson, G. M. Gill, H. C. Honey, T. Goulden, Stanley H. Jones, T. Hardie, Vernon Boys, C. M. Croft, G. C. Goldsmid, W. G. Brady, A. E. Broadberry, G. Evetts, A. F. Bezant, W. T. Dunn, Mr. Frank Jones, and Mr. F. Eliot Williams (Secretary of the European Gas Company).

GUESTS FROM FRANCE.

MM. R. Ellissen, President of the Société Technique; R. d'Estape, Vice-President; H. Laurain, Past-President.

Members of Committee.—MM. C. d'Aubenton, A. Baril, E. Chervet, R. Coudelou, H. Laedlein, R. Piaton, J. Ellissen.

Members.—MM. A. Bazille, M. Bernard, E. Berriat. L. Brille, P. Capuron, G. Chamon, A. Cornuault, L. Cros, G. Descours, F. Descours, R. Dupoy, J. Dupuis, C. Grandpierre, P. Gregory, Guernut, G. Heeley, A. Huon, T. Keclik, A. Largeron, A. Martin, M. Martin, H. Martin, L. Maurin, F. de Montravel, J. Ricart, G. Van Thournout, J. Verdier, J. Visseaux, A. Winkler, C. Martial.

After dinner the time was mostly spent in enjoyable intercourse between the French and English guests. There was, however, a short toast list. First of all the Chairman gave separately the toasts of "S.M. Le Roi d'Angleterre" et "S.E. Le Président de la République Française." These were very heartily honoured.

The CHAIRMAN subsequently submitted the toast of "La Société Technique de l'Industrie du Gaz en France." Mr. Jones, who spoke in perfect French, said: I have been asked, on behalf of my colleagues and myself, heartily to wish you welcome to this humble entertainment, associated as we are with your aims and purposes, evidenced by so many of us being members of your Society. We have seized the occasion of your official visit to the Institution of English Gas Engineers to demonstrate to you our friendship and goodwill. Indeed, since the brutal and fiendish attack on your country, we have, in common with our nation as a whole, felt such commiseration with your wrongs, such sympathy with your courageous resistance, that we were glad to fight, and many of us to fall, by your side, in vindication of the rights of mankind. We rejoice at the cordial, even affectionate, relations that exist between our two peoples; and it is our purpose to appeal to our shareholders to support the movement to aid in the reconstruction of our cities so cruelly and pitilessly devastated by the malignancy of your enemies. We agree with our noble King, who, in visiting the graves of your fallen heroes, and those of our lost compatriots, said that their lying together where they fought would demonstrate for ever the insoluble bonds which must bind us together. I ask our English guests to drink to the good fortune of your distinguished Society, and to wish that your too short visit may have been happy and enjoyable, so as to leave behind pleasant memories. [Applause.]

M. ELLISSEN, in reply, said: After many festivities, after numerous distractions among good friends whom one regrets to leave, there is nothing more pleasant than to pass a few hours "*en famille.*" This you have fully understood, and for this reason you have bidden us to this delightful gathering, to enjoy at the hands of the European Gas Company, on this occasion, our last dinner and our last evening in London—surely we may consider ourselves fortunate enough to be "*en famille,*" since there foregather with you this evening your chief colleagues from the Continent, and all of us are accustomed to work together from day to day in friendship for the common good. And, Gentlemen, as once more we give voice to the sentiments which particularly call us together—sentiments which bring us to share each of your successes, each of your joys—I may be permitted to tell you how deeply we share in to-day's great sorrow engendered by an abominable outrage, which has robbed your country of one of its greatest servants, and our country of one of its greatest friends. M. le Président, how many times had we all heard and respected your name before having the honour of your acquaintance! You stand at the head of a great Company, which has served as the prototype of our younger French Companies, which have adopted your methods and profited from your experience. You have sent out to us a host of distinguished engineers who cling jealously to your clean and vigorous industrial traditions. By your efforts you contribute largely to our gas industry and to our scientific research. The President of the Société Technique would be sadly remiss if he omitted to express to you his gratitude; and only your kindly wish that the number and the length of the toasts this evening should be cut down, prevents my enlarging on the subject. One favour, however, I would ask—that you should come more often to see us in France and in Paris. It is certain that by such visits we shall not lose professionally; and we shall be able to exchange experiences with you on our own ground (I might almost say actually on the ground of our battles), and profit widely thereby. Further, and here I speak more egotistically, on behalf of those among us who may be Directors of gas companies, I should like our Chairmen of Directors to know what the Chairman of an English company is like. I am not very sure that, by a little persuasion, you would not soon succeed in making them dance as you do with the "*les plus jolies femmes*" of our industry, and at the same time show them that a position of authority in no wise need interfere with good humour, high spirits, and eternal youth; and then, brightening by your lively personality our reception rooms, you will once more merit the gratitude of the French gas industry. [Applause.]

M. D'ESTAPE: Gentlemen, to-morrow morning we must leave London; and this is the last occasion before our departure that we shall meet together. Mr. H. E. Jones has just offered us a brilliant reception, and this morning and this evening again he has voiced most charming words of welcome. I therefore call upon you to raise your glasses to the health of Mr. H. E. Jones, Chairman of the European Gas Company.

M. ELLISSEN also made a few remarks.

Mr. JONES said: My sincere thanks for your cordial recognition, and for the too kind words of the proposer and seconder. I will say no more. But I ought to refer to the presence of such of our distinguished guests as may not be familiar to you. We have first Mr. Vernon Boys, the Physicist, Fellow of the Royal Society, renowned through Europe, who, among other investigators, established the weight of this planet. Then we have Mr Honey, Director of Gas Administration under the Board of Trade, who holds the fortunes of the gas companies in his hands. Wise, experienced, and judicial, his decisions are so fairly based as to be incontestible. Then we have Mr. Milne Watson, Governor of the Company whose enormous works you have seen to-day, and his able colleague Mr. Goulden, who like myself has a very long and wide experience. We have Sir Cyril Fitzpatrick, Member of the Council of Civil Engineers, and Chief Engineer of the Port and Works of London. Sir Robert S. Gardiner, of the Legion of Honour, and recently knighted by our King. There are also leading Engineers of the largest gas-works in the kingdom; and I must be pardoned if I omit their names in the need for shortening these thanks.

Return of the Prince of Wales.

In the course of the proceedings last Wednesday at the meeting of the Institution of Gas Engineers, it was unanimously agreed to send a telegram to His Majesty the King in the following terms:

> The Institution of Gas Engineers in general meeting assembled desire to offer your Majesty sincere congratulations on the safe return home of the Prince of Wales after his memorable and successful tour.—(Signed) HARDIE, President.

During the luncheon at Beckton on Friday, Mr. Milne Watson announced that the following telegraphic reply had been received from Lord Stamfordham, addressed to the President:

> The King heartily thanks the President of the Institution of Gas Engineers assembled in general meeting for their kind congratulations on the safe return of the Prince of Wales.

Mr. Robert E. Graves, C.B.E., who was Chief Inspector of Factories under the Home Office, left estate of the gross value of £3200.

The next meeting of the Eastern District of the Southern Association of Gas Engineers and Managers will take place on July 25 at the Institution of Gas Engineers, 28, Grosvenor Gardens, S.W. 1, at 2.30 p.m.

The Greatest Thing in Business.—At the meeting and dinner of the Incorporated Sales Managers' Association of the United Kingdom, held at the Holborn Restaurant on June 15, Mr. F. W. Goodenough (the Chairman of the British Commercial Gas Association) gave an address; the subject being "The Greatest Thing in Business." The speaker elaborated the need of more human affection and service and mutual confidence in our relations with our fellows rather than the old dogmas—*i.e.*, "Business is Business," and "All's fair in love and war," which lead to cut-throat competition and mutual distrust. The greatest thing in business was love. The audience received and discussed the question in a very sympathetic manner.

Proposed Junior Association for Wales and Monmouthshire.—Thirty students attached to various companies and corporations in South Wales and Monmouthshire who attend the gas supply classes conducted at the Cardiff Technical College by Mr. H. H. Langford, recently visited the Grangetown and Bute Terrace works of the Cardiff Gas Light and Coke Company. The arrangements for the visit were made by Mr. George Clarry (the General Manager and Secretary); and the students were shown the various processes in the manufacture and distribution of gas by Mr. H. D. Madden (Engineer) and his staff. After partaking of tea as guests of the Company, the prospects of forming a Junior Gas Association for Wales and Monmouthshire were freely discussed, and the hope expressed that the proposal would soon take definite shape.

THE INSTITUTION OF GAS ENGINEERS.

PROCEEDINGS AT THE ANNUAL GENERAL MEETING,

HELD AT THE

INSTITUTION OF ELECTRICAL ENGINEERS, VICTORIA EMBANKMENT, W.C.,

JUNE 20, 21, and 22, 1922.

President: THOMAS HARDIE, Esq., M.Inst.C.E.

REVIEW OF THE PROCEEDINGS.

[For Full Report see p. 788.]

FOR the Annual Meeting this year, we had a change of scene. Instead of Westminster, the members were summoned to the Victoria Embankment and, what is more, to the commodious home of the Institution of Electrical Engineers. This does not foreshadow any absorption of the gas industry by the electrical industry. The change was merely due to circumstances. However, we cannot help feeling a little envy over the housing of the Institution of Electrical Engineers. But it is an Institution which covers so many fields. There is electricity supply, electric railways, tramways, telegraphs, telephones, electric road traction, and so on; and therefore the sources of membership of the Institution are not confined as is the case with gas engineering. Hence the large membership, and the capacity for indulging in something more than offices. The building contains a large meeting room, with seating accommodation arranged very much after the fashion of the lecture theatre of the Institution of Civil Engineers. Altogether, it was as convenient as any place could be for the meeting; and set back from main thoroughfares it is well removed from the noise of road traffic. This is not the case with some of the places in which the Institution have met in previous years.

Though we were having a change of scene on this occasion, habits will persist. Men come and men go, but there seems a sort of tradition among the members of the Institution that before the sittings commence they should assemble and linger on the footways in front, or in the vestibule, of the building in which the meetings are to be held. It is not an objectionable practice, so long as it is confined to the time before the meetings. Among the groups on Tuesday morning were seen many men whose friendship is of years' standing; and there were faces that are not yet altogether familiar. However, gradually as greetings had been exchanged, the members filtered through the doors into the lecture theatre, and by the time the President, Mr. Thomas Hardie, M.Inst.C.E., Chief Engineer of the Gas Light and Coke Company, had taken the chair, most of the seats were occupied. There were a few blanks in the lower end seats, but these were mostly taken before there had been very much penetration into the *agenda*. The President was punctual, with his retinue of Vice-Presidents, councillors, and officials. On his left and right hand sides were his loyal helpers the Hon. Secretary (Mr. W. E. Price) and the Secretary (Mr. Walter T. Dunn). There was the ex-President (Mr. Thomas Goulden), and the Vice-President from troubled Belfast (Mr. J. D. Smith), and near him were Mr. S. Tagg, Mr. James Paterson, Mr. Stanley H. Jones, and Mr. J. H. Canning. Glancing at the other end of the presidential table were seen next to Mr. Goulden, Mr. Samuel Glover, Mr. A. E. Broadberry, and Mr. C. F. Botley. Other members of the Council could not find accommodation at the table, but they were near by.

The Presidential Address.

There was a little formal business; and then the President rose to deliver his address. He was heartily greeted. He has friends all over the kingdom. The North claims him; the South have now got him. Northern colleagues know they have sustained a loss; but they are glad it is one of themselves who has been selected for the highest post that British gas engineering has to offer. They know, too, that the exercise of a widely recognized skill and ability in the large sphere of operations is for the benefit of the gas industry at large. We are not going to summarize the address here. Points in it are emphasized in an earlier column. The analytical mind was seen throughout; the gift of clear expression and exposition was once more within our view. The man of reserved demeanour was speaking; and in every part of the address there was the deep thinker. The meeting hung upon the words; everyone was all attention. Here and there came expressions of assent. But these were the only breaks to the continuous hold that the President had upon the minds of those present.

The last words—words that well expressed the universal optimism as to the future—were hardly out of the mouth of the President when the whole meeting burst into enthusiastic applause, which only subsided when it was seen that Mr. Charles Wood was on his feet ready to propose what, in the circumstances, was almost a superfluity—a vote of thanks to Mr. Hardie for the address. Mr. Wood is an old friend. He performed his duty well—not from any sense of personal friendship, but with a sincerity that was felt by all. It was appropriate that a northern engineer should propose the vote; and satisfaction was added to when Mr. Goulden, the President's predecessor in the Chief Engineership of the Gas Light and Coke Company, rose to second it. This he did, with a genuine expression of the growth of an esteem for Mr. Hardie which commenced while he was up North, but has had much acceleration since he has come into still more intimate contact with him, and his work. The resolution was put to the meeting, and the applause signified the unanimous approval and pleasure of the members. Then a modest but sincerely grateful acknowledgment came from the President.

Losses to the Institution.

The presentation by the President of the annual report and accounts followed. He did not comment on the various matters dealt with in the report, which had then been in the hands of the members some little time, and considerable parts in it have been published in the "JOURNAL." He confined himself to the long list of names of members who have left the spheres of their activities. There are no less than sixteen of them mentioned in the report; four of them being honorary members—including the father of the present President of the Société Technique (M. R. Ellissen), and Mr. Thomas Duxbury and Mr. John West, both of whom were prominent in gas matters before most of those present had commenced the work that was to lead to professional

life. He mentioned the progress in gas engineering, and particularly in the mechanically produced works' economies, that John West had been instrumental in effecting. To him the industry owes much. Since the period covered by the report, other men admired for work and good qualities have departed—Mr. George R. Hyslop and the Rt. Hon. Sir Daniel Ford Goddard.

Our Own Loss.

May we here make acknowledgment, with the deepest gratitude, of the gracious terms in which the President referred to the loss the industry has sustained, and ourselves especially, by the death of Mr. Walter King. We will leave the report of what Mr. Hardie said to carry beyond the meeting the message of acknowledgment of good work and of friendship that ran through the life of our departed chief. His foremost thought in those upwards of fifty years of journalistic life—spent almost without a break until illness laid him aside—was for the industry. He had several temptations to link-up the "JOURNAL" with other industries; but they never matured. For the gas industry alone the "JOURNAL" had lived; for it, it was to continue to exist. As to his friendships, they spread throughout this country among succeeding generations of professional men, and to all quarters of the globe where there is gas supply and gas men are found. The "JOURNAL" office to gas engineers abroad is somewhat of a centre. When gas men came across the seas, and had no prearranged plans, they often called to see Mr. King and consult him regarding them; and, more before the war than since, correspondence was often addressed here to await gas men visiting this country. One more point. It used to be a claim of Mr. King that he had never, since he began to work for the gas industry, missed a meeting of the British Association of Gas Managers, the Gas Institute, or the Institution of Gas Engineers, save on two occasions, when illness prevented attendance. The period covered is over fifty years. However, we started this paragraph intending only to express our gratitude for the kindly references to Mr. King, and for the equally sympathetic reception by the members. But as the pen moves, thoughts come and recollections are revived.

Cheaper Gas.

The adoption of the report was seconded by Mr. L. Trewby; and then Mr. George Helps moved that it be referred back to the Council, on a point that was not alluded to in the report. That was the very reason for the amendment. The matter he had in mind was that the report did not show that the Institution were making any move in the matter of an inquiry as to what steps should be taken to provide the consumer with cheaper gas, when, in Mr. Helps' view, they could be supplied with more therms for the money they are being charged to-day. The members looked amused; and no one rose to second the amendment. Suffice it to say that the report and accounts were carried unanimously.

Aeration in Atmospheric Burners.

The work of the Gas Investigation Committee next claimed attention. Prof. J. W. Cobb introduced it. As in a few preceding years, so in this one it has taken a double course under different investigators. One part has Mr. James W. Wood as the Research Chemist; and during the past year he has resumed the investigation into the question of aeration in atmospheric gas-burners. The other part is Dr. Parker's research in gas manufacture—this time into carburetted water-gas manufacture, with waste-heat boilers. The researches into aeration in atmospheric burners were not sufficiently advanced to permit of conclusive data being presented; and so this year there is not a formal report upon the work and results, as is usually the case. It was considered better to leave it over until something definite can be submitted.

Prof. Cobb, however, made a general statement. It appears that the work the Committee have carried out on the efficiencies obtainable for different grades of gas in various appliances made plain the importance of aeration as a factor in determining the result realized in any case. As the grades of gas and conditions of use obtain greater variation, and depart more widely from normal coal gas, it becomes more difficult, but necessary, to forecast what will be the position as regards aeration resulting from any change that may be made. For instance, it is very necessary to know what will be the position in respect of aeration if the density of the gas is increased or diminished. Even such a simple thing as that has not been established with certainty. In the Professor's opinion, the very rudiments of the subject require to be established experimentally, which indicates our backwardness in knowledge of this subject. It is difficult to draw conclusions owing to the number of factors involved. There is the injector action pure and simple. We know what results from that in the way of primary aeration; but the extent of the aeration is influenced by other circumstances—such as the resistance offered by the burner tube, or construction or obstacle in the tube, or at the outlet. A difference will also be made by the position of the burner tube—whether it is upwards, downwards, or at an angle, because the gas-air mixture in the tube is lighter than the air outside, and a chimney or syphon effect is the result, which is intensified if the burner is lighted. This shows the variable factors that come into operation, the effect of any one of which may be obscured or even reversed. It seems that the only experimental method which will give the results wanted is one in which the problem is dissected into parts. The Committee therefore turned their attention to the study of the injector action in its simplest form. The full report of Prof. Cobb's remarks must be consulted to ascertain exactly what was done.

It seems too from Prof. Cobb's statement that results that have been obtained so far definitely discourage the idea that much can be calculated from formulæ as to the performance of a burner, except within narrow limits. There was also comment upon the fact that there has been a tendency in technical literature to simplify calculation by making assumptions which cannot be justified. These theoretical assumptions, it will be seen, he knocks on the head. Just a reference here to one of them. The American Bureau of Standards has put forward the view that there is a constant ratio (as distinct from equality) between the momentum of the injecting gas-jet and that of the air-gas mixture issuing from a burner, so long as the mechanical condition of the latter is unaltered, that this ratio is a characteristic constant for each particular burner, despite variations in gas rate, pressure, or specific gravity, and that it can be experimentally determined. In the tests at Leeds, this rule has not been found to apply with low velocities of air-gas mixture. It has been found to hold approximately in some of the burner tests when the velocity of the air-gas mixture was high. The more exact specification of the conditions under which the rule holds is very desirable, but entails further investigation. The Committee have found that within wide limits, when working with the same burner and jet, there is an increase in the aeration: (1) When the pressure (and therefore gas rate) is increased using the same gas; or (2) when the specific gravity of the gas is increased, whether the comparison is made at equal gas rates or at equal pressures. It is hoped by Prof. Cobb that at the next meeting of the Institution the results may be presented in a form which will do them more justice than was possible on this occasion.

Carburetted Water-Gas Plant, with Waste-Heat Boiler.

Then the members settled down to the consideration of the seventh report of the Research Sub-Committee of the Investigation Committee. Prof. Cobb introduced the subject; and Dr. A. Parker, who has had immediate charge of the investigations described in the report, gave a *précis* of it. One charge that cannot be made against the Research Sub-Committee is that their reports suffer from brevity and lack of detail. At last year's meeting, the report dealt with an investigation into blue water gas making; this year we are carried on to a study of carburetted water-gas plant, with an attached waste-heat boiler. The actual control of the plant was in the hands of Mr. G. C. Pearson, of the Birmingham Corporation Gas Department, to the Committee of which the industry owes so much for the facilities offered in these investigations. This report runs into fifty-four octavo pages, with a batch of twenty-two tables. So we are deeply thankful that, for the purposes of this review, the reporters have in the introduction incorporated the general results.

In the researches into the steaming of charges in con-

tinuous vertical retorts at Uddingston, it was found that the thermal efficiency of gas production rose from 54·4 p.ct. without steam to a maximum of 62·1 p.ct. with steam. It has since been calculated that, if the steam were raised by waste-heat boilers, the efficiency would be increased to 68·5 p.ct. In the blue water gas researches, it was found that, taking into account the steam required for the operation of the plant, the efficiency of gas production averaged 46 p.ct.; and it was calculated that, if the steam had been raised by a waste-heat boiler, the efficiency would have been increased to 56 p.ct. Now, producing carburetted water gas of a calorific value of 485 B.Th.U. gross, the thermal and chemical balances which have been constructed have shown that the efficiency of production of blue water gas in the generators of the carburetted water-gas plant, without taking into account steam required or raised, is 53 p.ct. The thermal efficiency of the whole carburetted water-gas process, with gas of 485 B.Th.U.—taking into account the steam required for the generators and for driving the blower, exhausters, oil-pump, and boiler-feed pump, together with that raised in the waste-heat boilers—averaged 68 p.ct. Calculations show that if the steam required had been raised externally in boilers with 70 p.ct. efficiency, the efficiency of the whole process would have been only 59·5 p.ct., so that the waste-heat boilers have brought up the over-all efficiency by about 8·5 p.ct. The efficiency of the production of the oil gas was approximately 90 p.ct.; and it is this high efficiency which causes the efficiency of the whole process to be so high as 68 p.ct. Therefore it will be seen that, in stating the efficiency of the production of carburetted water gas, it is necessary to mention the quality of the gas produced, for the over-all efficiency will be dependent on the amount of oil admixed with the blue water gas. It follows that with smaller quantities of oil, the over-all efficiency would have been lower than 68 p.ct., and would gradually have approached 53 p.ct. as the quantity of oil was reduced.

As to the waste-heat boilers, the thermal balances show that the total heat of the steam raised was only 41·9 p.ct. of the heat entering the boiler during the first test; and the corresponding figures for the second and third tests were only 49·6 p.ct. and 43·4 p.ct. Even in the first test, the steam raised was more than sufficient to supply the generators, and to drive the blower and auxiliary plant; and, in the other tests, more than sufficient steam was raised. It is suggested that the low efficiencies of the boilers might be improved by more satisfactory means for burning the combustible gas leaving the superheaters during the blow periods, which would enable the production of larger quantities of steam. Another hint is that before cleaning these boilers sufficient time should be allowed for them adequately to cool, in order to avoid strain of the fire-tubes and leaky joints.

The report gives a very full description of the carburetted water-gas installation at the Windsor Street (Birmingham) Gas-Works. The plant routine is also explained, as well as the measurements and weighings made, the sampling, and the measurement of pressures, temperatures, &c. Then there are the details of the tests, accompanied by the tabulated data. The carbon balances follow. The air supplied to the generators, carburettors, and superheaters is dealt with; and then the steam raised in the waste-heat boilers. Here it may be remarked as to the performance of the waste-heat boilers that the three tests mentioned show that the amounts of water actually evaporated per 1000 c.ft. of carburetted water gas made were 60·55 lbs., 69·88 lbs., and 61·11 lbs. The water was supplied at an average temperature of 20° C. If it had been previously heated to 60° C. by passage through the condensers, the amounts evaporated could have been increased by approximately 3·5 lbs. per 1000 c.ft. of carburetted water gas made.

Water balances, and the heat balances and thermal efficiencies of gas production, are next treated upon, together with other matters. Considerable information is given to the measurement of temperatures, as well as to the composition of the blue water gas and blow gas at the different stages of the operation of the plant. In appendices the methods of analysis are described; and the data employed in the calculations, with some supplementary data, are also given.

Reverting briefly to Prof. Cobb's introductory remarks, he emphasized the point as to the efficiency of gas production from oil being high, so that carburetting is on a sound thermal basis, if only the price of the liquid fuel cracked (whatever it may be) is brought sufficiently low. He also mentioned that among experimental difficulties that have to be overcome, one of the chief is the measurement of temperature, which, in a process with such rapid alternations, is no simple matter. The report shows that results as ordinarily obtained by the use of a thermo-couple protected with a sheath, and calculations based upon them, are of more than doubtful accuracy. He acknowledged the amount of work and care involved in obtaining the figures used in the preparation of the balance-sheet.

No Criticism, but Many Comments and Inquiries.

There were several contributors to the discussion; and they turned attention to many points. The fact that the investigation had been on plant under ordinary working conditions was regarded as a merit. There was the possibility of improving the efficiency of the waste-heat boiler, mentioned in the report; and there was the thermal efficiency of the oil-gas production. It was Mr. J. P. Leather who pointed out that the 90 p.ct. efficiency was taking into account the heat value of the tar and so on produced from the oil. With 21 p.ct. of carbon in the tar, there is still room for improvement, so far as the question of turning oil into gas is concerned. Some of the speakers alluded to naphthalene; and Mr. C. F. Botley referred to the fact that naphthalene can be produced freely by wrongly cracking the oil. Having regard to the waste-heat boiler, it seems to him that a temperature had been maintained in the superheater which should not be necessary for complete cracking of the small amount of oil necessary to produce 485 B.Th.U. gas. Mr. H. R. S. Williams was another speaker; and he was followed by Mr. Thomas Goulden, who fixed upon one of the main features of the report, which was that the authors have shown that, by the action of the blast gases alone, enough steam may be raised for that particular unit of plant, and something to spare. Among other points, he alluded to the necessity of letting-down the whole plant when one had to give attention to the waste-heat boiler. In the Gas Light and Coke Company they are trying to avoid this by coupling two boilers to two sets of plant so that the plant can be interchanged, and either boiler be worked. As to naphthalene, of course the more oil one has to deal with, the higher the temperature necessary. If anyone had trouble with naphthalene in water gas, he should advise him to look carefully after the temperature. It was learned from Mr. R. E. Gibson that at Liverpool they are setting up in the laboratory an experimental apparatus for testing oil, which will operate in accordance with working conditions. From this it is hoped to get results which will give a more proximate indication of what the oil will do. The efficiency figures in the report will, in his opinion, be very useful indeed. Mr. F. W. Cross wanted to know to what extent the ordinary boilers were cut-off from the waste-heat boilers in the tests. Other speakers were Mr. C. H. Carder and Mr. F. H. Robinson; and there was Dr. Parker's reply. He pointed out that the calculated efficiency of oil-gas production was 90 p.ct., but the heat in the gas produced was only about 70 p.ct. There was with this plant really no trouble with naphthalene. He also mentioned that the total volume of hydrogen in 1000 c.ft. of carburetted water gas was less than in the amount of blue water gas required to produce it. This is a question which is going to be investigated. He also alluded once more to the low efficiency of the waste-heat boiler, and he reiterated his belief that it was due to the fact that they had not a proper mixture and combustion of the gas before entering the boiler. As to Mr. Cross's question, the other boilers were shut down altogether, the valves were closed, and the plant was run on the waste-heat boiler alone. These are only a few points touched upon in a discussion the full report of which will be found very instructive.

The New President and Junior Vice-President.

There was much satisfaction on learning that Mr. J. D. Smith, of Belfast, is to be the successor of Mr. Hardie in the Presidential Chair; also that Mr. James Paterson, of Cheltenham, has become a Vice-President, so that, all being well, there will be the gratification of welcoming him to the presidency after Mr. S. Tagg has been through the chair.

Liberation of Nitrogen and Sulphur from Coal and Coke.

The report of the Institution Gas Research Fellowship was taken first in the afternoon. This is a highly inter-

esting investigation, by Dr. A. C. Monkhouse (Institution Gas Research Fellow) and Prof. Cobb, into the liberation of nitrogen and sulphur from coal and coke. The first part was submitted in a report last year; and this report gives the details of further experiments. The object is to ascertain the behaviour of the nitrogen in coal and coke under the influence of heat, in an inert atmosphere (nitrogen), in hydrogen, and in steam. The experiments were made with: (*a*) A soft coke prepared at 500° C.; (*b*) a medium coke, prepared at 800° C.; and a hard coke, prepared at 1100° C. The results may be summarized thus: By heating the 500° C. coke in an inert atmosphere, nitrogen was liberated; but up to 800° C., only one-third of this nitrogen was obtained as ammonia—the rest being free nitrogen. No appreciable quantity of ammonia was obtained above 700° C., although above this temperature the coke continued to lose nitrogen. At a temperature of 800° C. with the 500° C. coke, an atmosphere of hydrogen, in addition to any preservative action in retarding the dissociation of ammonia once formed, exerted a specific action in liberating a portion of the nitrogen as ammonia which would otherwise have remained in the coke. By prolonged treatment with hydrogen up to 1000° C. in stages, 68·2 p ct. of the nitrogen of the coke was obtained as ammonia. With the 800° C. coke, the attack of hydrogen was feebler, and the ammonia recoverable smaller. With the 1100° C. coke, the hydrogen had no power of attack up to 1000° C. By gasification of the coke with steam, the whole of the nitrogen was obtained as ammonia, the liberation of ammonia being much more rapid (above 600° C.) than with hydrogen. The liberation of ammonia from hard coke by steam was much slower than from soft coke, and very much slower at 800° than at 900° C.

Regarding the second part of the inquiry as to the liberation of sulphur from coal and coke, the three cokes used were prepared at like temperatures; the coal used being Yorkshire (Warrenhouse) bituminous. It is believed that the nature of the coal probably affects the sulphuretted hydrogen results more than the ammonia results, because of the influence of sulphur combined with such inorganic elements as iron and calcium. Of 100 parts of sulphur present in the coal, the quantities occurring in the 500° and 800° C. cokes were 56·4 and 50·1. (*Cf.*—Of 100 parts of nitrogen present in the coal, the quantities occurring in the 500° and 800° C. cokes were 78·4 and 50·3.) On heating them in nitrogen, very little sulphuretted hydrogen was evolved up to 1000° C., and very little sulphur was lost from the cokes. On heating the 500° C. coke in hydrogen, sulphuretted hydrogen was evolved steadily up to 800° C., when it fell away in quantity. Although the heating in hydrogen was prolonged (forty hours at each temperature), sulphuretted hydrogen was still coming off steadily at each temperature, when the ammonia evolution had nearly ceased. At 900° C. the evolution of sulphuretted hydrogen quickened again in a manner which suggested attack on some compound previously resistant. When treatment ceased at 1000° C., 93·8 p.ct. of the sulphur of the coke had been obtained as sulphuretted hydrogen. No effect corresponding with the dissociation of ammonia was noticed. On heating in steam, the loss of sulphur was rapid; but probably not more rapid than with hydrogen up to 800° C. Completion of decomposition could, however, be secured in steam at that temperature when the attack of hydrogen had become negligible. Probably the sulphur compound was attacked by steam at 800° C. which required a rise of temperature at 900° C. if hydrogen was employed. With both hydrogen and steam, and particularly with a mixture of the two, the sulphur in the 1100° C. coke was attacked vigorously at lower temperatures, such as 800° C., at which the nitrogen compounds (and the carbon) were little affected.

The report was introduced by Prof. Cobb, who concisely showed the main features of the results. He also expressed the opinion that, in view of the possible changes in the gas industry that may be brought about by the extended gasification of the fixed carbon by steaming in gas-retorts, water-gas manufacture, or complete gasification, with air or steam, or with air and nitrogen, the study of what happens to the nitrogen and sulphur compounds of the coke under the various conditions will be both interesting and useful. Dr. Monkhouse summarized the report itself. A subscriber to the discussion was Mr. J. P. Leather, one of whose points was that if by steaming we are going to have more sulphuretted hydrogen from vertical retorts, then larger purifiers will be required. The President, Mr. W. J. Smith, and Mr. S. Glover also took part in the discussion, which was brief; and, as will be found in the full report, rather took the shape of inquiries to Dr. Monkhouse, and answers by him.

Internal Corrosion and Modern Gas Practice.

The report of the Life of Gas-Meters Joint Committee is a very useful one—not only on account of the results of new investigation and other information contained in it, but because it opens with a summary of the five principal changes in gas practice which have brought about the more rapid deterioration of gas-meters, and refreshes memory as to the remedies or palliatives proposed. The report was presented by Mr. B. R. Parkinson. The change from lime to oxide purification has resulted in a large proportion of the carbon dioxide and hydrocyanic acid being left in the gas. There is also some increase in carbon bisulphide allowed to go forward, which, by interaction with any possible ammonia, produces the most destructive salts. It should not be necessary to draw any further attention to the extreme importance in efficiency in the ammonia-washing plant. The effects of the impurities named have been aggravated by high-temperature carbonization dissipating those constituents which have been the natural lubricants and preservatives of the distribution system. This means that greater attention must be paid to the removal of certain impurities, particularly hydrocyanic acid. It is noted that the increased use of oil gas in the case of the Gas Light and Coke Company has resulted in a marked diminution in the percentage of unaccounted-for gas, due possibly to the effect of the oily constituents on the meters. Another cause of trouble is that aqueous vapour in gas has been given much greater freedom of action by the absence of oily constituents. It may act either as a vehicle for corrosive salts or as a simple aid to corrosion in conjunction with such agents as oxygen and carbon dioxide. Greater attention should therefore be given, both on the works and district, to the subject of temperature and aqueous condensation. A film of heavy oil on the water in station meters and gasholders is suggested. Paraffin vaporization is a remedy or palliative prescribed both for corrosion and naphthalene troubles; but it has been established that a gas saturated with water will not hold much paraffin vapour. Oxygen in the gas arising from the introduction of air for the revivification of oxide has added another simple agent of corrosion. The action of oxygen on metals as a corrosive agent in the presence of moisture is well enough known; but its action on the leathers of dry meters is not sufficiently realized. When a dry meter is taken out for repair, the inlet and outlet connections should be corked immediately. Blue water gas may contain sulphur dioxide, which is another agent of corrosion. In view of this, it is important that the oxide in the water-gas purifiers should be slightly alkaline. This can be effected by either the addition of ammoniacal liquor, soda ash, or slaked lime.

Hydrocyanic Acid and the Chalk Process.

There was considerable satisfaction in learning that the chalk process for the extraction of hydrocyanic acid which has been invented by the Chemist to the Committee (Mr. J. G. Taplay), and patented by him and the Gas Light and Coke Company, has in working proved successful, and is to be placed at the service of the gas industry, by application to the Secretary of the Company. In the report indebtedness is expressed to the Company, as well as appreciation of the research made by Mr. Taplay. Briefly outlined, the process is as follows: There are two ways of working—by solid chalk in a scrubber, or by cream of chalk and water in a washer. This will make it possible in many cases to utilize existing plant, or spare plant, of either description. The position of the unit should be between the tar-extractor and the ammonia washer, for it is essential to the reactions that the gas should contain ammonia, but should be free from tar. There is also an incidental advantage in removing the hydrocyanic acid prior to the oxide purifiers, for the small amount absorbed by the oxide impairs the efficiency of the latter for sulphuretted hydrogen purification *pro ratâ*. If a scrubber be used, the solid chalk should be broken into lumps varying in size according to the plant; and this chalk is periodically washed with clean water or weak liquor (not from the hydraulic main). The product, which is ammonium thiocyanate, must be removed

as formed. Alternatively, by using a washer, the gas is passed through an aqueous solution of bicarbonate of lime. In either case the chalk appears to act as a catalyst; the reaction becomes cyclic, and hence may be carried out as a continuous operation. It is hoped that this method will provide a simple and expeditious, as well as an economical, means for the removal of hydrocyanic acid from gases, and for the cheap production of ammonium thiocyanate as a bye-product.

The report also contains particulars of certain cases of trouble investigated during the year, as well as information regarding the new standard list of dry gas-meters rated according to the maximum (efficiency) working capacity, to which last matter the attention of gas engineers is urged.

More Points Elicited by Discussion.

The discussion ranged over many points, some of which were advanced by Mr. Thomas Glover. Among the questions he raised was as to whether the authors had investigated the effect of corrosive condensates on purifiers. The remedy he suggested was to line the purifiers with ferro-concrete. He also observed that the Committee were looking at the question of the removal of ammonia from the point of view of the life of gas-meters; but he finds an advantage in leaving a trace of ammonia in the gas to assist purification. Where the purifying material becomes rather acid, the ammonia has a corrective influence. As to oxygen, if this is properly regulated, it ought not to escape the gauntlet of five or six purifiers. None ought to escape the purifiers because of the mischievous effects on the distribution system and the leathers of dry meters. Some very practical points were also raised by Dr. Parker, Mr. Thomas Goulden, Mr. Botley, Mr. S. Glover, and Mr. Williams, while Mr. A. W. Glover particularly called attention to the section of the report dealing with the new standard list of dry meters. Regarding Mr. Goulden's remarks, he suggested that if a film of oil was used on the surface of the water in gas-holders, it should be changed from time to time, so that it does not get supersaturated with naphthalene. He also mentioned that in the Kensal Green district of the Gas Light and Coke Company they had had no difficulty with either mains or meters since they put down a Botley plant; and Mr. Botley confirmed this from his experience at Hastings. Satisfaction was expressed by Mr. S. Glover on the discovery of such a simple process for dealing with hydrocyanic acid. Mr. Taplay made a most instructive reply. Only one or two points from it here. He says he believes the corrosion of the cast-iron plates of purifiers is solely due to ammonium sulpho cyanide; and he is experimenting to see what can be done towards its absorption. But this experiment will take some months before it is complete. If tarring the plates does not prove successful in preventing the corrosive action, then some other means will be adopted —say, oxide paint—at any rate, something cheap. As to ferro-concrete for covering the plates, Mr. Taplay is not sure that it would not be disintegrated in a comparatively short time by these corrosive ingredients. More information was given by him regarding the chalk process for dealing with hydrocyanic acid. He mentioned that a scrubber for treatment of the gas by chalk is about to be put into use; and something like 2½ million c.ft. will be put through it per twenty-four hours—in the winter time, there will be more. Then a washer is going to be tried in which the chalk will be used in the form of a cream. Mr. Parkinson also replied. Altogether the discussion was highly interesting; and the replies extremely so. The full report will amply repay perusal.

The Refractory Materials Report.

The report of the Refractory Materials Research Committee was next brought before the members by the Chairman (Mr. A. E. Broadberry, M.Inst.C.E.). Part of his remarks were directed to showing the grave disability under which the Refractory Materials Association were working owing to the inadequate financial support rendered to them.

In his Address, delivered at the morning sitting, the President acknowledged that since the Committee have been at work—now about a decade—there has been an appreciable improvement in refractory materials; but there is room for more. This testimony, so far as it goes, but coming from his large experience, will be a satisfaction to the manufacturers. At the same time, changes have come in the gas industry, and with them still greater demands upon the qualities of the refractory materials employed in gas manufacture. In their report, the Committee point to the agreement of view as to great improvements having, since the specifications have been in operation, resulted in the manufacture of firebricks, retorts, &c., not only in the gas industry, but in others dependent upon refractories. But what has been done does not suffice. More is required; and the report states the position concisely. Experience (as was anticipated) has shown that considerable amendment is required in the standard specification and tests; and the work of revision is already well in hand. In regard to the retort specification, it was only contemplated that retorts would be made from fireclay with an admixture of grog; but it is necessary at the present time to add silica and siliceous materials, aluminous material, and carborundum, or anything else that is suitable, and also mixtures of any of these substances.

Clause 3 of the specification has needed much careful attention. The test-piece is required to show no signs of fusion at a given temperature. It sounds simple enough; but the difficulty is to determine what is and what is not a sign of fusion. No other words, however, seem to make a suitable substitute. Dr. Mellor specially wishes to point out that squatting, signs of fusion, rounding corners, &c., all fail in the specification. In the notes and appendix on this clause, there was an attempt to define signs of fusion; but experience has shown that the definition is not satisfactory. The best way to meet all views appears to be to define signs of fusion as being "when the angular edges of the test-piece begin to lose their angularity when heated under conditions stated." Neither should the test-piece, which should be 1½ in. high by ¾ in. base and the same shape as the cone, show signs of bending, nor should the matrix show signs of melting. The specification will probably be finally amended somewhat in this way. Most experimenters prefer to grind the test-piece to shape, as the triangular cone is more easily formed by this method; while others prefer to chip it as nearly as possible to shape, as the angular edges are then more susceptible to the rounding effect due to fusion.

It appears, too, that the contraction test has also been difficult to carry out in practice. The size specified, 4½ in. long by 4½ in. wide, was found too large, and test-pieces are now preferred 2½ in. to 3½ in. by 1½ in. to 2 in. by 1½ in. to 2 in., and instead of being placed horizontally should now be placed vertically. Difficulty has also been experienced with taking the measurements on account of varying behaviour of various parts of the test-pieces; and an endeavour is being made to overcome this difficulty by allowing a tolerance of 1 p.ct. for experimental error in order to secure better agreement between tests made by different experimenters.

The specification for contraction or expansion has been stiffened up by reducing it to 1 p.ct., instead of 1¼ p.ct. Similarly corresponding alterations are required in respect of firebricks, blocks, and tiles, and in regard to silica bricks, blocks, and tiles. The work of revision will soon be complete, and the new edition of standard specifications will shortly be in the printer's hands.

The work connected with refractory materials was largely new when it was taken in hand; and this report shows conclusively that the specifications needed the supplement of practical experience. This has now been obtained; and its impress will be found in the revision that is to be effected in the specifications. The report includes, in two parts, a statement, by Miss D. A. Jones, B.Sc., as to work done in connection with the standardization of the after-contraction test; and a contribution by Mr. A. T. Green on the thermal conductivity of refractory materials at higher temperatures. These additions to the literature of the subjects treated upon are for study; and they do not lend themselves readily to the rigorous condensation needed for a review of this kind.

There was comment upon, and considerable criticism of, the report. Dr. Harker of the National Physical Laboratory opened the discussion; and Prof. Cobb found scope for a large amount of criticism on several questions. There were so many points that to attempt condensation into a few lines would have no usefulness; and so it will be better to leave readers to study the full report. Therefore we will not allude to the remarks of Mr. Leather and Mr. Rhead nor to the reply made by Mr. Broadberry.

The Benevolent Fund.

The number of members present at the opening of the proceedings on Wednesday morning, when the affairs of the Benevolent Fund were under consideration, may be taken as a good sign of a larger interest. This is as it should be; for the cause is a deserving one, and worthy of a genuine interest, and more subscribers. The business, of course, was more or less of a routine character.

Some Gas-Burners and a Moral.

There was a full audience present by the time Dr. Charles Carpenter was called upon to read the first paper on Wednesday. The members know from long experience that, when Dr. Carpenter takes in hand a matter of the kind, he does it well; and there is always something of solid worth to be obtained from his utterances on technical matters —whether to do with gas manufacture or utilization. They had placed in their hands a paper beautifully illustrated. Ranged on a long bench in front of the President's table, was a splendid array of burners and fittings of a character that speaks of advances in both design and efficiency. The whole paper was directed to the points that the lighting load is something that should be retained, and that the retention is a matter of high-class fittings and burners, suitable for the purpose, and withal efficient. Standardization, the least possible claim upon the consumer in respect of the maintenance of efficiency, and convenience in utilization, are among other questions dealt with by the author.

Turning to the paper itself, the first part is historical; and the names of men who contributed to advances in gas lighting are brought to memory one after the other. They are names which gas men honour, as of those who have contributed largely to the promotion of convenience and utility in the world. Then came a condemnation of the shoddy burners and fittings that flood the market. The industry has never attempted to do anything to lay down conditions as to what is required, nor to standardize burners, mantles, or anything else affecting lighting, nor have any tests been devised for gas-fittings. It is, however, many years since the South Metropolitan Gas Company directed attention to the question of supplying burners with fixed proportions for gas and air. And from the introduction of the upright burners in the street lamps of South London in 1900, the principle of fixed air and gas has given complete satisfaction. The same principle was afterwards applied to the inverted form of burner; and many thousands of burners made on this plan have been in use in South London. But this carries with it the necessity for supplying standard gas. Dr. Carpenter did not tell the long story of research and investigation that this all involved; but, by the aid of a competent and diligent staff, the problem was solved. The only possible objection which may be raised is that, where exceptionally high gas pressure is experienced, economical usage depends on the operation of a tap at the fitting. The adjustment is of the simplest possible nature, and in practice the objection will be found to be pointless. A matter to be noted is that long experience has shown that burners without gas and air adjustment other than is provided by the tap can be designed which will afford an efficiency deviating but little from the pre-ascertained value, provided the calorific value of the gas does not depart from the declared standard by more than 25 B.Th.U.

Now standard glassware, mantles, fittings, &c., of every description are carefully considered by the Company in the matter of design and mechanical structure, and their physical properties and specifications defined and drafted; and the manufacturers are asked to conform. This is a result of collaboration on the part of all the departments concerned. In the paper the convenience of bayonet joints is pointed out, and the effects of dust in the air are discussed. Then the effect of the form of the issuing jet is dealt with. The results of the greater or less area of the surface of the jet upon air entrainment is shown by recent experiments carried out by Dr. J. S. G. Thomas in the Company's physical laboratory. From these it may be anticipated that a greater degree of primary aeration is to be effected by the use of a multiple-hole ejector than by the use of a larger single-hole one. With certain provisos, the conclusion is correct. The orifices of the jets must be disposed so that the air-entraining powers of the several jets are not reduced by mutual interference of the jets. Such interference reduces considerably the degree of primary aeration effected, and tends to render the jets unstable—producing in the case of a gas-burner an unstable and flickering flame. There was also reference to the most vital part of the illuminating device—the mantle itself. Dr. Carpenter holds that the industry should lay down experimentally the conditions necessary to make the article it requires.

In the concluding part of the paper, Dr. Carpenter not only earnestly appealed for a wider appreciation of burner design, but says it rests upon the gas-engineering profession to make gas not only the light of the present, but of the future, if it will but take a due share of the tasks involved in perfecting its uses and spreading the knowledge of them far and wide. He exhibited a diagram (which is reproduced elsewhere) showing curves representing the load lines of two adjoining companies supplying gas to one of the largest cities. The diagram was submitted as justification for the belief that there is a moral associated with the paper. The paper was beautifully illustrated.

Approved Ideals, with Difference of Opinion on Fixed Adjustments.

There was an admirable discussion on the paper; many speakers taking part in it, including the President, Mr. G. Helps, Mr. Thomas Goulden, Mr. H. E. Jones, Mr. J. Ferguson Bell, Mr. H. E. Copp, Mr. F. W. Goodenough, Mr. C. F. Botley, Mr. W. J. Liberty. The President, like many other speakers, referred to the high-class character of the paper and the (in several respects) very proper ideals that it represented. He thought the primary suggestion in the paper was one that must be carefully considered in the light of circumstances. He referred to the fact that the Institution could take steps in conjunction with the manufacturers for the making of appliances that are quite safe. On the question of standardization, he pointed to the inevitableness of gas varying in quality and composition to a great extent in different districts. Of course, Mr. George Helps was out for lower-grade gas. He appeared somewhat to deprecate the lighting load, in view of the fact that, in his experience, one cooking consumer was worth at least ten lighting consumers. This deprecation Mr. Goulden countered. In his view, lighting must not be neglected; the heating business can to a large extent take care of itself. He thought the diagrams that Dr. Carpenter had shown were most instructive. Several of the other speakers, with the President and Mr. Bell, strongly supported the author in his plea for high-class fittings and burners, and urged that in gas showrooms nothing but the very best in point of appearance and of high efficiency should be shown.

Opinions differed considerably regarding fixed gas and air supplies, in view of the fact that it is impossible to have standard gas in the circumstances of all districts. It was Mr. Goulden who, in this connection, pointed out that in the present transition stage of the gas industry and the developments that are coming along in connection with gas production, the standardization of gas is a thing which cannot be established universally. He agreed, however, that the industry ought to have its own specialists in connection with such an important matter as the production of the burners by which gas has to be consumed. There were several references to the diagrams, one coming from Mr. Jones, who pointed out that comparisons of the kind are very unsafe, in view of the totally different conditions existing in even adjoining districts. He instanced Central London and the suburbs. This was a point, too, that was made by Mr. Goodenough in an allusion to the variations that have come about in lighting demand through the characteristics of a district. Take, for instance, the West-End, with its Royal Palaces, leading hotels, restaurants, mansions, clubs, and so on, in which respect that part of London is altogether unique. He is strongly of opinion that there is no part of the business of the gas industry that can be neglected. Every part, lighting included, must receive a due share of attention to its progress and maintenance.

Some of the speakers, including Mr. Jones, Mr. Ferguson Bell, and Mr. Copp have tried the "Metro" burners, and Mr. Jones bore testimony to the long life of the mantles on the burner. Mr. Bell has used the same burners for some years, and Mr. Copp is an admirer of them; but they must be accompanied by standard gas. The whole meeting was at enmity with shoddy burners, particularly so Mr. Botley. One view of Mr. Liberty is that it would be a good thing if the Institution appointed a Committee to go into the

question of the standardization of gas-burners for lighting purposes.

Reference to the full report of Dr. Carpenter's reply to the discussion will show that fixed air and gas adjustment is applicable not only to straight coal gas, but to mixtures of coal gas and water gas, especially where the proportions are fairly constant. For some fourteen years he has had the "Metro" types of burner in use at Westminster, both for lighting and heating purposes. From his remarks there is no doubt that he was extremely gratified with the excellent reception his paper had received, and with the recognition that was made by the speakers that, though they were not all in agreement as to his ideals being attainable in every area, they are such that the nearest approach possible to them should be sought.

Increasing the Rate of Carbonization.

Dr. Geoffrey Weyman—through the facilities afforded him at the works of the Newcastle and Gateshead Gas Company and by the Chief Engineer (Mr. Frank Tarratt)—has added to the obligation of the industry to him for the freedom with which he has communicated to it the results of his study and work on the important subject of increasing the rate of carbonization. A narrative of work done by him in this direction constituted the next contribution to the proceedings. Dr. Weyman started off with the assertion that the rate at which coal is carbonized is plainly fundamental to the economics of gas production. While this is perfectly obvious, it is frequently overlooked; and it is a paper such as he contributed that accentuates, and impresses on the mind, that which is obvious. If the rate at which coal is carbonized is brought from an incorrect degree to the correct one, then labour charges are reduced, maintenance charges are diminished, and capital cost is lessened almost in proportion to an increase in rate. But he says there are other less obvious, but none the less important advantages in a rapid rate of carbonization. In addition to the rate of carbonization, two other important factors have to be kept in mind—the thermal yield in gaseous form per ton of coal carbonized, and the calorific value of the gas. But the calorific value to be declared should only be fixed in the first place with due regard to plant and conditions of manufacture, and especially of the type of coal carbonized. It does not by any means follow that thermal yields per retort and per ton are inversely proportional to calorific value. From observations of the working of a continuous vertical retort plant, it has been found that increase in thermal and volume output per retort is usually accompanied by increase on the tonnage basis. The author refers to curves which demonstrate this. Roughly speaking, it is seen that the greater the rate of gas or therm output, the greater the yields per ton. There is instructive comment in the paper on these curves; and then the author enters in detail into the experimental work upon which he has been engaged.

Summarizing the more important conclusions reached, it is found: (1) An increase in the rate of carbonization caused by alteration in the chemical and physical conditions—due for example to the use of a more suitable type of coal, or a more suitable size of coal particle—is accompanied by improvement in the calorific value of the gas and of the thermal and volume yields per ton of coal. Improvement is seen in every direction. (2) Very considerable increase in the rate of carbonization may be obtained by the selection of those coals which give up their gas above a minimum rate. Except in cases of oxidized coals, the calorific value of the gas, and consequently the thermal yields, are higher for an increased rate. (3) When an increase in the rate of carbonization is caused by an increase in carbonizing temperature, the results are complicated by the fact that the portion of the gas evolved on the outside of the plastic layer is subjected to an increased degradation; and this opposes the tendency of the higher rate to give gas of superior calorific value. Up to the end of a certain time, the calorific value of the higher temperature gas is smaller than that of the lower temperature; but, volume for volume, there is a slight balance in favour of the high-temperature gas. After a certain period, when the coal at high temperature is nearly carbonized, the calorific value falls off very rapidly; while the coal at low temperature is still producing gas of moderate quality.

An increase in volume and thermal yields per ton follows an increase in rate due to a higher carbonizing temperature, which it is impossible to obtain at lower temperature. Volume for volume the calorific value of the higher temperature gas falls off at a slightly greater rate than the lower temperature gas; but a greater volume of gas is evolved from the former, which quickly makes up for the deficiency.

Coal Character and Retort Shapes.

The discussion on the paper was a good one. It is a type of paper that Mr. Thomas Glover thinks should be encouraged, and so do most gas engineers. In fact, all papers that are the results of investigation should be welcomed, as research is the best way to an expansion of knowledge. The author did not escape some criticism, particularly from Dr. Lessing and Dr. Parker. But generally there was approval of the points made; and opinions were expressed based on empirical or theoretical grounds, rather than positive research, as to the various factors that influence the transmission of heat through retorts and the coal charges. Mr. Glover is very insistent upon the point that the shape of the retort has great influence on results; and he has found that, though there are objections to them, retorts of rectangular section are the best for the transmission of heat into the charges. The condition of the coal is a very important matter—particularly in horizontal retorts; and Mr. Glover is very much opposed to dusty coals. The usually accepted carbonizing rate of one hour per cwt. of coal, he indicates, must vary with the physical characteristics of the coal. The importance of the time element was also emphasized by Mr. Dru Drury. Dr. Lessing, among other points, contested the theories of Mr. Glover regarding the rate of carbonization with coal in fine particles. A long contribution was made to the discussion by Dr. Parker, one of whose remarks was that the results of carbonization must differ according to the retort system employed. There is, for instance, a difference between vertical and horizontal working. Dr. Davidson spoke of the plasticity of coals, from which horizontal working does not suffer; but there are coals that are so plastic that they cannot be properly carbonized in some retort systems—for instance, those working at low temperatures. As the full report shows, Mr. W. W. Townsend, Mr. T. F. E. Rhead, and Mr. F. J. Bywater also contributed to the discussion; and Dr. Weyman replied.

Reconstruction at Beckton.

In the afternoon of Wednesday, a useful paper to those who were proposing to visit Beckton on Friday was read by Mr. W. B. Leech, the Engineer of the station. It was not only useful in that regard, but it was technically valuable. Beckton has of late been undergoing a sort of metamorphosis of its plant; but there is one thing that cannot well be altered, and that is the lay-out of the plant. Everything was so vast that, when the works were originally designed, much that was done will for long tether the engineers of the Gas Light Company to certain lines of reconstruction and development. The gas-making capacity at the time the reconstruction work described in the paper was decided upon was 70 million cubic feet per day; and the total capacity, when reconstruction work in hand is finished, will be about 93 million cubic feet. During the past three years, the principal reconstruction work has been: (1) The provision of a new unit of carbonizing plant inside the shell of No. 7 retort-house; the unit to supply 6 million cubic feet. (2) Redesign of the producer-gas generators in other retort-houses (260 producers in all). (3) New coal and coke handling plant for No. 7 house. (4) Extensions to the purifying plant. (5) Provision of an extension to the oil-gas plant of 12 million cubic feet per day. (6) Erection of new engineering and wagon-building shops. (7) Provision of new water supply and filtration plant.

The fact that a million tons of coal are purchased for use at Beckton, and that varieties of Durham coal have to be used, with due weight being given to other factors, resulted in horizontals being adopted for the house. The retorts are 23 ft. long, and 24 in. by 18 in. ⌂ shaped, capable of carbonizing 20 cwt. of coal in twelve hours. To burn off the charge in the time fixed, and to obtain a full yield of therms, it has been found that a combustion chamber temperature of 1400° C. was necessary. Fireclay retorts at the time were adopted; but with the experience since gained in experimental settings, it has been decided to use in future silica

segmental retorts as the standard. An average of many readings has shown the difference between combustion chamber and retort temperature to be 260° C. for fireclay, and 200° C. for silica retorts. The advantage of 60° in the retort for the same combustion chamber temperature is a material one. The author then gave particulars as to the deepening of the producers. Details were supplied as to the methods of insulation. The front walls of the settings are insulated by a course of asbestos bricks, 2¼ in. thick; and at the top of the bench there is one 3-in. course of insulating bricks. Some unsuccessful attempts at steaming horizontal retorts are described in the paper. There are also references to the use in two settings, in No. 1 house, of Congdon pipes, towards which the author appears to have a leaning from the labour-saving point of view. But the separation of the tar and liquor, he says, is no easy matter; and the pumping plant for circulating the liquor would be costly in a large installation.

The paper also deals with the various types of stoking-machines which are working, or have worked, in recent times at Beckton. The author gave information from his experiences with these machines, but the interesting facts must be gathered from a perusal of the paper. Details of the coal and coke plant are also furnished; and in connection with the latter, some very favourable information appears as to the use of transporting and quenching benches on the Drake system. Turning to the purifying plant, Mr. Leech referred to the use of ferro-concrete in the construction of purifiers. But he found some leakage from these when an air-pressure test of 44 in. was applied. Most of the leakage was in the decking. Mr. Leech believes that the best means for making concrete purifiers gas-tight would be to render the inner surfaces with super-cement to a thickness of ⅜ in.

A Discussion on Details.

The discussion was a good one. The speakers were particularly interested in the details which Mr. Leech had given them, more particularly because, as Mr. Percy Hoyte said, most gas engineers are at present extraordinarily interested in reconstruction or extension work. But they cannot all experiment in the same way as is possible in such large works as those at Beckton. There was comment by Mr. G. M. Gill on many points, among others as to the temperature of 1400° C. in the combustion chambers. He mentioned that there is no material, except silica, that will stand that temperature. Dealing with gas yields, he also submitted that the make per retort is a good deal more important than the make per ton. It will be found that Mr. W. M. Carr was much interested in the information given regarding charging-machines; and he had some pertinent and practical questions to ask regarding the work done by the respective machines. Silica segmental retorts have been tried by Mr. Dru Drury. He finds them highly refractory; but carbon collects at the joints, and gives some trouble when using a pusher. Mr. Drury was also attracted by the great improvement Mr. Leech has realized by increasing the depth of his producers. In his own case, his producers are somewhat shallow; and there are difficulties in the way of deepening them. After hearing what the author said, he is going to reconsider the matter of doing this. Mr. R. E. Gibson, in the course of his remarks, told how at Garston he is using a machine which passes the coke out of the retort-house by means of the power of the pusher on the other side of the bench. The coke is pushed through a tube of special construction, which tube can be elevated to any height or turned in any direction—even for feeding the producers. The tube protects the men from heat. The machine has been working continuously since last March, and so far quite satisfactorily. Mr. H. H. Collett, of the Danish Gas Company, had also some inquiries to put to Mr. Leech. He was particularly interested in the working of the De Brouwer bands. Mr. J. Fisher also mentioned the use of rubber bands in America.

Reception of the Société Technique.

Thursday was a red-letter day. By ten o'clock the lecture theatre was filled, and much of the standing room was occupied. It was the morning for receiving the President (M. R. Ellissen) and some forty-five of his colleagues of the Société Technique—the first official visit since the war. Everybody was pleased. And when the President appeared with M. Ellissen and the Vice-Presidents and other officers of the Société, together with Sir R. S. Gardiner and members of our Council, there was great enthusiasm and applause, in which there was a feeling of affection as well as of greeting. The address of welcome from Mr. Hardie was couched in very gracious terms, in which, too, there was genuine heartiness. The same attributes were in the expressive words of M. Ellissen in his reply. The speeches would only suffer by any attempt at summary; and we will leave them as they stand in our general report to speak for themselves. After the welcome, and the impressive acknowledgment, the visitors left the meeting to do a kind act, which is referred to elsewhere.

A Recording and Integrating Gas Calorimeter.

The visitors having left, the members settled down to listen to what was really a lecture on the recording and integrating gas calorimeter, invented by Prof. C. V. Boys, F.R.S., one of the Gas Referees. A paper on the subject had been prepared by him; but Prof. Boys has lived in this work so long, and knows every particle of his invention, the purpose of each part, and has gone to such infinite pains in achieving a desired end, that he delivered himself of a description of the instrument, told why he had done this and that, and the purpose of every part, with a fluency and completeness that fascinated those present.

This recording and integrating calorimeter marks, as does the Gas Regulation Act, another stage in our industrial advance. This at any rate was very generally felt at the meeting; though, before anything more definite is said, the instrument has to be subjected to working trial away from the hands of the inventor. It was the importance of the subject to every gas undertaking that kept the lecture theatre filled with an interested audience, who were frequently moved to laughter by the humour which Prof. Boys introduced into a matter of scientific and technical importance. The instrument was described in our pages last week; and the paper appears this week, so that it would be almost superfluous to indicate in brief terms here the character and operations of the calorimeter. The attainment of great accuracy in an instrument that is to stand guard between gas consumer and gas supplier is a matter of considerable moment to both parties. This Prof. Boys showed in the opening of the paper. A calorimeter subject to vagaries cannot be tolerated.

There was an almost universal acknowledgment of the ingenuity and skill displayed by Prof. Boys, who has produced a recording calorimeter of simplicity, and with vital parts interchangeable, so that the instrument may be readily maintained in proper condition. Mr. George Helps made statements which show that he does not understand the instrument, but nevertheless he does not think much of it. Prof. Boys later accepted Mr. Helps' knowledge of the matter at the critic's own valuation. A more competent critic is Dr. Harker, who refers to the instrument as a great triumph; and he pointed out that the little integrating device would do for a gas undertaking what it would take a lot of people to do. Certain parts of the instrument were criticized by Mr. G. L. Hodgson; but Prof. Boys cleared up any misapprehensions that gentleman may have been entertaining. On the other hand, Mr. J. H. Canning was struck with the way Prof. Boys had adjusted his material to the purpose. He is of opinion that similar adjustment should be made in the case of ordinary burners. The general feeling, after the exposition and discussion, was that a satisfactory recording calorimeter is not to-day the impossible thing that but nine months ago it was thought it would be.

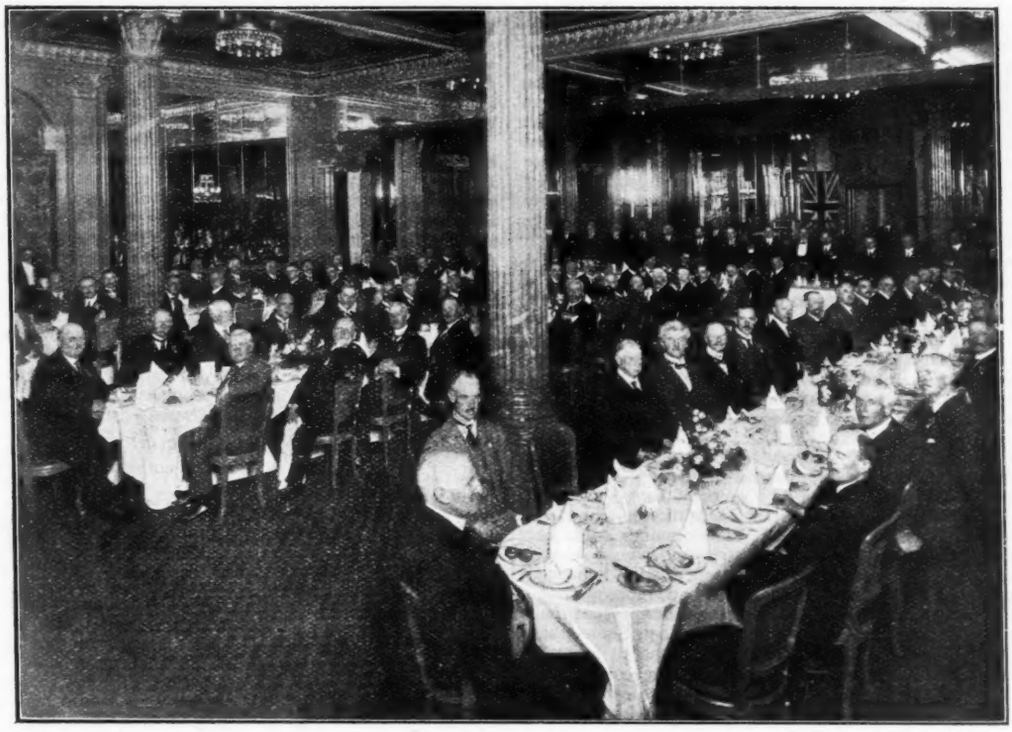
Concluding Business.

This brought us to the end of the technical proceedings; and then there was a little final business. The Presidents of the French, American, and Italian Associations were elected honorary members. A hearty invitation was extended to the members, by Sir William Coates, to visit Belfast for their next annual meeting; but, on the suggestion of the President, it was agreed, while thanking Belfast and Sir William, to make final decision when nearer the date of the meeting. Votes of thanks of a cordial nature were passed to the President and Mrs. Hardie, and to everybody who has worked for the Institution or contributed to the proceedings at the meeting—including the Hon. Secretary (Mr. W. E. Price) and the indefatigable Secretary (Mr. Walter T. Dunn). So ended the sittings which constitute an annual meeting second to none in the Institution records.

LUNCHEON IN HONOUR OF THE SOCIÉTÉ TECHNIQUE DE L'INDUSTRIE DU GAZ.

Immediately after the conclusion of the technical proceedings at the sitting on Thursday morning, the President (Mr. Thomas Hardie) and Council of the Institution gave a luncheon at the Savoy Hotel in honour of the President, Vice-Presidents, and visiting members of the Société Technique.

It was a highly successful event, and it gave another opportunity for fraternizing and further cementing the good fellowship which exists between British Gas Engineers and their professional brethren of France. To the immediate right of the President was M. R. Ellissen, the President of the Société Technique. Next to him was Mr. D. Milne Watson, the President of the National Gas Council; and there followed M. Laurain, Mr. Thomas Goulden, M. E. Chervet, Mr. H. E. Jones, M. R. Piaton, and Sir W. F. Coates (Lord Mayor of Belfast) To the left-hand side of the President was Lord Riddell, the President of the Society of British Gas Industries, and M. R. d'Estape, M. Ch. d'Aubenton, Sir Dugald Clerk, M. A. Baril, M. R. Coudelou, Sir R. S. Gardiner, M. H. Laedlein. Noticed among other guests were the Gas Referees (Prof. Boys, Mr. W. J. Atkinson Butterfield, and Dr. Haldane). There were also Mr. Charles Hunt and Mr. F. W. Goodenough. The vice-chairs, by the way, were occupied by the President-Elect (Mr. J. D. Smith), Mr. Samuel Tagg, and Mr. James Paterson. Altogether there were covers laid for 116, and there were only three vacant seats.



A FLASHLIGHT PHOTOGRAPH TAKEN BEFORE THE LUNCHEON.

After luncheon, the President submitted separately the toast of "His Majesty the King" and "The President of the French Republic." Both toasts were enthusiastically received, and the National Anthems were sung.

"LA SOCIÉTÉ TECHNIQUE DE L'INDUSTRIE DU GAZ EN FRANCE."

Mr. THOMAS GOULDEN, Past-President of the Institution, in proposing the above toast, said he felt sure that the President would have submitted it much better than he could do. He could only think that Mr. Hardie had taken so many of his (Mr. Goulden's) burdens upon his shoulders, that he thought he might do him a turn by relieving him of one to which he was solely entitled. He (Mr. Goulden) was not going to complain in this particular case, because he had great pleasure in doing it with the recollection in his mind of the visit to France three years ago—in the autumn of 1919—when he had the privilege of forming one of a delegation to France of the Institution of Gas Engineers. It was a most delightful visit; and it was one in which they were almost embarrassed by the kindness of the welcome and the unceasing endeavours of their hosts for their happiness, and for an enjoyable time while in their country. They certainly did their best; and that they completely succeeded was the opinion of everyone of the delegation that went over there. Not only was the visit enjoyable, but it was interesting, although he was bound to say it was one to be regarded with very mixed feelings. On the one hand, they had the unceasing endeavours of their hosts to make the visit pleasurable, and there were the warmest sentiments. They welcomed them very heartily; and the social part of the visit was certainly much enjoyed. Through the good offices of their French colleagues, they visited some of the devastated districts of France, and those present could imagine the sympathy that was evoked in the hearts of the visitors for the unfortunate populaces of those parts of France from which the inhabitants had been evicted—that was, the devastated country from Rheims to Berry-au-Bac, and from Arras to Lens. Lens was an unforgettable sight. Not a single house, even of the smallest size, had been left standing, and the few inhabitants who were there had their residences in dug-outs. It was a sight they would never forget. Great cities in ruins, and the country between howling waste, rusting barbed-wire entanglements, decayed trenches, and only too many of the cemeteries that contained the glorious dead of both nations. He reflected during the tour there that they were only able to enjoy the hospitality of their hosts, and to tour through their country, because of the *entente cordiale* existing between the two nations. Many years previous to the war they had been bonded together by mutual ties of sympathy. War came; and those bonds were naturally strengthened by the common cause of the peoples of the two nations in the maintenance of the pledge they had made to defend the cause of the weak against the strong, and by putting into practical effect the mutual determination that civilization, in Europe at any rate, should not be swamped by the wave of scientific barbarism that was set in motion by the rulers of the German Empire. But the sacrifices made by the two nations in throwing back that wave were dreadful to contemplate; and they would long suffer from their effect. It was no less needful now in the times of peace—true they were troublous times of peace—that they should maintain the same sympathy, the same feelings as to the necessity for united endeavour to reconstruct Europe. That alone enabled them to combat successfully the vast horde of soldiery that they met in the war. It was good to have meetings like this. They got to know one another. They came into personal contact; and they learned to realize personally what they each were. If they did not visit one another, they were more or less abstract quantities; but coming into this intimate personal touch as they did, they learned to esteem one another, and to know one another better. He hoped that more meetings of this sort would take place. They were very necessary, and most desirable between all sections of the two nations. If the peoples were really united and one at heart, it did not matter much what the politicians or journalists might do. The members of the Institution and their friends of the Société Technique, he was sure, were equally determined to weld the members of both bodies in the closest bonds of friendship. They were united by common aims in the service of the peoples they served. They could gain much by

the exchange of views with regard to professional work; and they were able to indulge in that exchange of views at meetings of this sort. It was all to the good that they should have these gatherings. He did not think he need say more, except to ask the members of the Institution and the British visitors present to rise and drink to the continual prosperity of the Société Technique. With the toast he coupled the name of M. Robert Ellissen.

M. ELLISSEN, the President of the Société Technique, then responded. He spoke in French; and M. Ellissen, jun., kindly translated the acknowledgment. He said the members of the Institution had that morning the kindness to receive with indulgence—a very needful indulgence indeed—his few words of grateful acknowledgment, uttered in a language he liked very much but which, unfortunately, did not reciprocate at his will. He therefore asked the members to permit him to convey his thanks in French. He must say he was still under the hold of a persistent emotional feeling. That morning, in the name of his colleagues, and his comrades in war, on behalf of all among those present whose kith and kin fought, and, alas! too many of them fell, he laid a new French tribute on their glorious Cenotaph. Then in the solemn religious silence and meditation of the Abbey, they revived the emotions of the heroic struggle when side by side, welded as it were by the same conviction and enthusiasm, the united British and French protected and maintained the liberty of the world which was now recovered. He was certain he expressed the innermost thoughts of his colleagues present who fought at the war when he recalled the magnetism that drew them to the British comrades they met through the hazard of war. An undefinable congeniality brought them nearer, and personal feelings of sympathy quickly sprang from their intercourse. He always found the explanation for this in their indebtedness to this country for part of their professional education, for the scientific and technical notions derived from it by them. As gas engineers they paid constant attention to the labours of British gas engineers; and those labours were the agents that enabled them to know their British colleagues better, and to appreciate to a greater extent their unrivalled national qualities. Though only about fifty of the members were there that day—many being prevented from accompanying them by professional duty—the feelings he expressed corresponded with those of all French gas engineers. On behalf of them all, he brought their tribute of admiration for the work of British gas engineers. Owing to the great number and compactness of British industrial centres, to the proximity of the gas-works to their coal supplies, and to their mechanical industry being greatly developed, owing to the regulations between the authorities and the gas undertakings, British gas-works were and always would be ahead in new processes. In fact, what a wonderful succession of prominent engineers there had been in the gas industry—from such pioneers as Mr. Thomas Graves Barlow and Dr. Litheby (both of whom his own father prided himself to reckon among his masters) down to—only mentioning their last endeared deceased—Sir George Livesey and Sir Corbet Woodall. The welcome that Sir Corbet gave them in 1913 at the Jubilee of the Institution he could not remember without being deeply moved. Their names could not disappear from the annals of the industry, and would remain there for the good of them all. He had been greatly honoured in paying a tribute to British science. He had, moreover, the pleasure to express in the name of all his colleagues present their friendly gratitude for their reception that day. Their Society had been delighted in accepting on several occasions the invitation of the Institution, and enjoying their cordial hospitality. After each new visit, they had developed a deeper remembrance, and an increased enthusiasm. The present reception induced him to think beforehand that their remembrance of this year's too short stay would be as keen and faithful as the previous ones, and would contribute to the strengthening of their common sympathy which might be rightly compared to a monument so firmly built by mutual co-operation that no human power, no stormy element whatever, could shake it even slightly.

"THE INSTITUTION OF GAS ENGINEERS."

M. H. LAURAIN proposed the next toast, "The Institution of Gas Engineers." He said M. Robert Ellissen, the President of the Technical Society of the French Gas Industry, had the pleasure that morning of thanking the members of the Institution for the kind invitation sent to the French "*gaziers*." He expressed the affectionate feelings which they all felt for British gas engineers. He was particularly happy to take the opportunity of this coming to England to thank, in their own country, the members of the Institution for having accepted, two years ago, his invitation to come to France, and to visit with them the battlefields of Artois and Champagne. That pilgrimage they made together in the countries wasted by the war, where their sons side by side died in defence of right and liberty—that pilgrimage made them feel that their societies were linked together for the pursuit of progress, and for the economic struggle, just as their glorious soldiers were united during the awful universal clash. M. Francis Rouland, the Administrator of the Parisian Gas Society, who was the President of all the reunions when their British colleagues visited Paris, had chosen him to tell them how sorry he felt at not being free to come on this occasion to England. And especially he gave him authority to greet Mr. Thomas Goulden, whose kind words during his stay in Paris he had never forgotten. The awful storm which during five years blew on the world had provoked a very acute crisis in the gas industry. However, the effects of that crisis were weakening every day. They could hope that soon their dear industry would be as prosperous and thriving as before the storm. During and since the war, many important transformations had been made in the production, the distribution, and the sale of gas. He was satisfied that much greater progress would soon be realized, because, during the last few years, the public services with which they were entrusted became more and more important from the social point of view as from the economic one. Therefore, gas engineers were ever applying their thoughts to the progress of their industry. They watched carefully over their works; and they were particularly concerned in the new way of selling gas by the therm. He apologized for this digression; but he had set his heart on paying homage to the knowledge, the activity, and all the other eminent qualities of his British colleagues. Greeting the memory of departed English gas engineers, he drank to the prosperity of all gas engineers and of the whole gas industry.

The PRESIDENT (Mr. Thomas Hardie), in acknowledging the toast, said it was his privilege as President of the Institution to thank M. Laurain and the members of the Société Technique for the way in which the toast had been proposed, and accepted by them. The members of the Institution appreciated very much indeed the very kind words that had been used; and they were very pleased to learn that something of the work that the Institution did was of so much interest to their friends on the other side of the Channel. That morning, at the meeting, he suggested that closer work between them—more knowledge of what each other were doing—would be beneficial to both. Efficiency was what the Institution were out for—efficiency in the retort house to economize and conserve coal; efficiency in the purifying-house to ensure purity; efficiency in the distributing plant that they might give a plentiful supply of gas under constant and sufficient pressure; efficiency in the sales department that the public might not lose any of the benefits which they could obtain by the use of gas for all purposes for which it was suitable. In their quest for efficiency, they instituted research work both individually and collectively. But they were not above obtaining information from elsewhere; and such meetings as they had that day, and such visits as this of the French Society, were very helpful towards that end. Such meetings were advantageous in that they broadened their views; they made them look at things from a wider angle; and they certainly taught them not to place too narrow a limit, or too great importance on their own work, or on anything they themselves did. He had great pleasure indeed in thanking M. Laurain for the kind words in which he had proposed the toast, as well as the French visitors for the hearty way in which they had endorsed those words.

"KINDRED ASSOCIATIONS."

Mr. J. D. SMITH (the President-Elect) said he had pleasure in submitting the toast of "Kindred Associations," including the National Gas Council, the British Commercial Gas Association, and the Society of British Gas Industries. It was a toast which he could confidently anticipate would be received with the enthusiasm which it deserved, more particularly when it was associated with such popular and well-known names as Mr. Milne Watson and Lord Riddell. They were just approaching the end of their proceedings; and he thought he could say, without fear of contradiction, that this had been one of the most useful and interesting annual meetings of the Institution which they had had. He felt sure that the impressions of it and the conclusions which had resulted from their discussions would bear abundant fruit in due course, and have their bearing upon the future of the great key industry which they represented. About half-a-century had elapsed since the first of these meetings was held. It had been a period of great development in every direction. Science, commerce, engineering, chemistry, and not least their own branch, had been completely transformed. The limit of evolution had by no means been reached; and they must see to it that, as the world moved onward to the larger destiny appointed for it, they marched as hitherto in the van of progress. In this development, in this progress, they could not over-estimate the assistance and driving force which had been put forth by the kindred associations which they were honouring in the toast. The National Gas Council, formed during a period of grave difficulty and national peril, had more than justified its existence in the great assistance it had rendered in legislative matters, and in the co-ordinating of the many interests of gas undertakings. It had undertaken the onerous task of keeping a close eye upon all events in Parliament that concerned them. Somebody had said that Parliament was the greatest producer of gas in this or any country. As a figure of speech, that might or might not be true. He left that for Lord Riddell; but in the sense that it literally controlled by legislation all their activities, there was something to be said for the statement. This showed how essential it was that there should be constant vigilance, and the closest and most painstaking scrutiny of every piece of legislation which had a bearing upon the industry. He thought the members would agree with him that they had been splendidly served in this direction, and that the National Gas Council could not have been better led than Mr. Milne Watson had led it. The British Commercial Gas Association, after many years of good work, was still to the fore in protecting the interests of gas under-

takings, and in initiating active propaganda work; and probably the greatest tribute to its success was the fact that the electrical industry were devoting their energies to the development of a similar Association. The Society of British Gas Industries had grouped the interests of contractors and manufacturers of gas plant and apparatus in a manner which was beyond criticism; and at all times they had shown a willingness to co-operate with the other Associations in promoting the best interests of the industry. Touching upon personalities, it would be impossible for him to express in a few words all they owed to Mr. Milne Watson for the success which had been achieved by the National Gas Council and British Commercial Gas Association; and their earnest and sincere wishes and hopes were that they might continue to profit by his advice and influence. Lord Riddell was a very welcome guest. He was, he understood, the only man who had ventured to hold a different opinion from the Prime Minister, and lived with the friendship unimpaired. The difference, he gathered, however, related to golf; and each had charged the other with being the worst player. Under his able presidency, they might predict a year of success and progress by the Society of British Gas Industries. It gave him (Mr. Smith) great pleasure to submit the toast, coupled with the names of Mr. Milne Watson and Lord Riddell.

Mr. D. MILNE WATSON, as President of the National Gas Council, said he had to thank Mr. Smith for all the kind words he had used about him personally, and regarding kindred associations, for which he was asked to reply. He assumed that, as the toast had not been coupled with a name particularly representing the British Commercial Gas Association, he might, in his position of Past-President, reply also for that body. It was exceedingly gratifying, he was sure, to be able to feel that the National Gas Council had been accepted by the Institution of Gas Engineers in the way it had been. The National Gas Council, as Mr. Smith had told them, came into existence in a time of national stress, when it was felt there was nobody exactly doing the work which was necessary to be done during the war and immediately after it. But whatever success the National Gas Council might have had had been due, in great measure, to the support which he had received from the technical members of the profession. There had not been a bit of jealousy shown to the National Gas Council by the Institution of Gas Engineers for years. The Institution was practically the only organized body representing the gas industry. It was followed, many years after its foundation under other names, by the British Commercial Gas Association. Both these bodies had their special work—the Institution being occupied principally in technical matters, the "B.C.G.A." with matters of propaganda and pushing gas sales, and bringing gas to the knowledge of the people of this country. But there was lacking a body which could devote itself to matters connected with the political side of the industry's work. Unfortunately perhaps for the gas industry in this country, it was the special object of legislation. It was never left alone. If it was not being attacked in one way, it was being attacked in another. The only way to hold its ground was that it should have a strong body like the National Gas Council which was prepared to champion that great and ancient industry in Parliament and out of Parliament; and it was particularly gratifying to find that the work of the National Gas Council was so whole heartedly appreciated by the Institution of Gas Engineers, which was its very much elder brother. Not only had the Institution as a body given it the support that was necessary for the successful operation of the Council, but he might say the individuals who formed the membership of the Institution had accorded the greatest support by coming to the meetings of the Council, and attending to its business, without which they would not have succeeded, as he held they had done. If he might reply for the British Commercial Gas Association, what he had already said was also very true regarding that body. The Institution had supported the work of the British Commercial Gas Association, realizing that it was not only the making of good gas in the retort-house that they must consider, but that the gas had to be sold, and to the satisfaction of the consumers. With the three bodies—the Institution, the National Gas Council, and the British Commercial Gas Association, all working together in harmony and cordially, the view before them was very bright indeed. He thanked them for the kind way in which the toast had been received.

Lord RIDDELL, responding on behalf of the Society of British Gas Industries, said he had been indeed flattered by the observations that Mr. Smith had made concerning him, because it was the custom of the Society of British Gas Industries, which he had the honour to represent, to elect as their President somebody who who knew nothing whatever about gas. In fact, he believed he was the only member of the company who was in complete ignorance of the subject. [Laughter.] Therefore, he could regard the gas industry from a detached point of view. But he should like to say this in regard to the remarks that Mr. Milne Watson had made—that the gas industry would be in a sorry plight indeed without the makers of gas plant and gas appliances, and those makers were the members of the Society which he represented, although the name of that Society had been omitted from those mentioned by Mr. Milne Watson. When he was in Washington, he heard President Harding make a very interesting speech. He was speaking on the subject of internationalism. He said that America did not want to see Broadway running into Bond Street, nor did they want to see Broadway running into the Rue de la Paix. He said they wanted to see all those streets running side by side. Reduced to more common language, this meant that America was not in favour of what they might call internationalism, or the amalgamation of nationalities. He cordially re-echoed President Harding's sentiments. He thought it would be a disastrous thing if the world lost the advantage of the special qualities of the great nations of which it was composed. On the other hand, though it was undesirable that the streets he had mentioned should run into each other, it was most desirable that the people who walked in those streets should be on good terms with each other, and should each know what another was doing. [Hear, hear.] That was where conferences of this sort were good for the world. Such conferences as that which they were celebrating that day he believed formed the true road to peace in the world. It gave him very great pleasure to be there as an outsider, and he congratulated them very heartily upon the success of their conference.

"THE VISITORS."

Sir DUGALD CLERK said he had to propose the toast of the visitors, and to couple with it the name of Sir William F. Coates, Bart., the Lord Mayor of Belfast. He was delighted to find that the Lord Mayor of Belfast was able to obtain leisure from his onerous duties to come and join the members of the Institution of Gas Engineers and their friends from France. Among the visitors they must include Sir William, Mr. D. Milne Watson, Prof. Boys, Dr. Haldane, Mr. Butterfield, and others. As to Prof. Boys, he had performed a great many services for the gas industry, and he took a most friendly interest in everything they did both from the scientific and practical points of view. He (Sir Dugald) had spent an hour with him the previous day, at the Institution of Electrical Engineers, in learning about his new recording calorimeter. It was indeed a marvel of ingenuity. Prof. Boys had displayed the same ingenuity in attempting to provide the gas industry with a recording calorimeter to carry out the intention of the Gas Regulation Act, as he showed when he spent much time in certain cellars at Oxford endeavouring to weigh the earth, and he did even that more successfully than any other man had been able to do. Among the other visitors was Lord Riddell, who was at the head of the Society of British Gas Industries. He (Sir Dugald) had a great interest in this Society, because he happened to be its first President in 1906. The Society had elected men as their Presidents who to some extent were outside the industry; but he did not think Lord Riddell was so ignorant of the gas industry as he tried to make out. But some of the men who had been Presidents of the Society did know about gas, and were actually members of the Institution of Gas Engineers. He also saw among the visitors Mr. Griffith, the Secretary of the Society, who had held that office with great credit ever since its formation. Then again, it was always pleasant to see their friends of the Technical Press—the representatives of the "GAS JOURNAL" and of the "Gas World." He had noticed that morning in the "JOURNAL" that their old friend, Mr. Walter King, who was almost always a visitor on such occasions as this, had passed away; and this caused them all the keenest sorrow. The gentlemen who represented the visitors were all very powerful in contributing to the prosperity and advancement of their great industry. Many problems of a scientific, economic, and political nature entered into the work of the industry, which carbonized no less than 20 million tons of coal, and had been expanding its work from the beginning of the last century when the Gas Light and Coke Company was founded by Mr. Winsor. He gave them the toast of "The Visitors."

Sir WILLIAM F. COATES said he rose to express on behalf of the visitors the great pleasure they had had in accepting the kind invitation to be present on that occasion. To him it was a considerable honour to have his name coupled with this toast; and he hoped he might claim that the fact of his being invited showed that those present did not look on the great city which he represented in Northern Ireland as other than still a part of the United Kingdom. He was especially gratified to be present when their French friends were here. It was most appropriate that the two nations who shared the trouble of gas in a form of which they preferred not to speak, should now be united in research work in connection with this element for the good of their communities. Digressing for one moment, he wished to congratulate his fellow citizens on the fact that Mr. Smith had been appointed President of the Institution for the coming year. He also wanted to congratulate the Council upon their choice, for the reason that, during the two days he had had the honour of coming in contact with members of the Institution, he had learned that men prominent in the gas world had been Presidents of the Institution; and therefore he hoped they would not consider him unduly egotistical when he prophesied for their incoming President a happy and useful year of office. He was sure that the Institution would gain further prestige and importance during the year. Most of them knew that an invitation had been extended to the Institution to meet next year in Belfast. He certainly hoped that the steps the Northern Government of Ireland were taking would be quite successful, and that they might next year assemble in Belfast, and have a happy and pleasant time. He could assure them that there would be nothing wanting in the welcome they would receive there; and it would give them still greater pleasure if it were possible for their French friends to join them on that occasion.

This concluded one of the several interesting and gratifying events during the visit of our French colleagues.

VISIT TO BECKTON OF THE INSTITUTION AND THE SOCIÉTÉ TECHNIQUE.

On Friday morning, by invitation of the Governor (Mr. D. Milne Watson), the Deputy Governor, and Court of Directors of the Gas Light and Coke Company, the members of the Institution of Gas Engineers and of the Société Technique de l'Industrie du Gaz en France visited the Company's Beckton Works. The number participating in what proved to be a very enjoyable day was fully as gratifying as had been the attendances at the business sessions of the meeting. Two steamers had been chartered to take the party to Beckton; and, favoured by fine weather, the trip was a delightful one. Punctually at 9.30 the first steamer moved away from Westminster Pier; and about a quarter-of-an-hour later, the other followed. On reaching Beckton, which was gay with French and English flags, the duties of hosts were genially undertaken by Mr. Milne Watson, Mr. Thomas Goulden, Mr. Thomas Hardie, Mr. W. B. Leech, and other members of the staff of the Company.

As soon as everything was in shape, there was a solemn duty performed by a group—including Mr. Milne Watson, M. Ellissen, and Mr. Hardie—who proceeded to the handsome memorial (a photograph of which appeared in last week's issue of the "JOURNAL") erected to the employees of the Company who fell in the war, and there stood bareheaded for a short space, in silence. After this, M. Ellissen stepped forward and reverently placed at the foot of the pillar a handsome wreath on behalf of the Société Technique; and he was followed by Mr. Hardie, who placed by its side another beautiful one from the Institution of Gas Engineers. It was a brief ceremony, which deeply touched all who witnessed it—a fitting recognition of the sacrifices made by those who have died, and one which has assuredly done something to tighten still further the bonds of friendship between the living.

Railway wagons were found in waiting to take the different groups on the tour which had been pre-arranged for each; and this admirably organized feature of the visit merits a further word of explanation. On the journey down, booklets containing a description of the works were distributed, each of which was marked "Route No. 1," "Route No. 2," or "Route No. 3;" and in accordance with the number on their particular booklets, the visitors joined one or other of the parties. At the end of the booklet was a plan showing in red the route that would be taken by this party—partly walked and partly traversed by rail—and so no confusion could arise. There was another very thoughtful feature. The booklets contained a card pointing out that the plan showed the plant which would be visited before lunch, and adding: "Any visitor who may desire to make a more thorough inspection of some particular portion of the plant than time will permit of in the morning, or who may wish to see some other part of the works which the morning visit does not cover, should sign this card, when arrangements will be made for the desired visit after lunch." The parts of the works closely inspected in the morning included No. 7 retort-house (which had been described by Mr. Leech in his paper), the water-gas plant, and the erecting and machine shops and the big repair workshops, equipped with all manner of up-to-date tools, in an examination of which a good deal of time was spent, while many appreciative remarks were made. Of course, each tour could cover only a small portion of the works; but the routes had been mapped so as to reveal clearly to the visitors the immense scale on which the station has been laid out.

Eventually, all roads led to the luncheon marquee; and here there was a reception by Mr. Milne Watson of the guests, who must have numbered something like 600. Seated on Mr. Milne Watson's right at the luncheon was Mr. T. Hardie, and on his left M. R. Ellissen; while among other names of those at the top table may be mentioned the following: M. R. d'Estape, Mr. Harry Jones, Mr. T. Goulden, M. H. Laurain, the Hon. Clive Bigham, Sir R. S. Gardiner, Mr. W. B. Leech, Mr. J. Paterson, Mr. Samuel Glover, Mr. W. E. Price, Mr. John Bond, Mr. John Young, Sir Henry Maybury, Mr. R. G. Shadbolt, Mr. Henry Woodall, Sir A. Denny, Mr. Robert Martin Holland-Martin, Mr. J. D. Smith, Mr. H. C. Honey, Mr. S. Tagg, Sir Joseph Davies, Mr. W. L. Galbraith, Mr. A. E. Broadberry, Mr. W. Doig Gibb, Mr. R. W. Foot, Mr. Charles Wood, Mr. E. J. Hutchence, and Mr. T. Glover. The honouring of the toasts of "The King" and "The President of the French Republic—our Great Ally" was accompanied by the playing of the National Anthems.

A FORMER VISIT RECALLED.

Mr. MILNE WATSON said it was a very great pleasure indeed to the Gas Light and Coke Company to welcome so many visitors there that day. There were three distinct toasts which he would like to propose; but in order to save time, he would put them together. He would therefore ask them to drink to the health of "The Institution of Gas Engineers, the Société Technique de l'Industrie du Gaz en France, and Our Visitors"—coupling with the toasts the names of M. Ellissen, Mr. Thomas Hardie, and Sir Archibald Denny. The Company had had many visits from distinguished parties at Beckton during the last few years; but, with shame let it be said, it was not since 1876 that the Institution of Gas Engineers had visited these works officially. Now, by a strange coincidence, this was the year in which their late esteemed Chief Engineer, Mr. Thomas Goulden, entered the service of the Company. As their French friends would say, "*Le voilà*." They had to retire Mr. Goulden before the Institution of Gas Engineers would come back again. [Laughter.] Well, having secured this desired object by elevating Mr. Goulden to a seat on the Board [Applause], the Company were now permitted to receive the Institution once more. Whether the fault had been the Institution's or the Company's he did not know; but he hoped it would not be so long before they visited Beckton again. Otherwise, he feared there would be very few left of those now present to again receive the hospitality of the Gas Light and Coke Company. Before this malign influence came upon them, between the years 1870 (when these works were first started) and 1876, the Institution paid no less than three visits to Beckton—in 1870, 1872, and again in 1876.

He had taken the trouble to look up in that esteemed paper the "GAS JOURNAL" just what happened in 1876; and he found that then the late Mr. Robert Morton was President; and he noticed that on this occasion Mr. Corbet Woodall read a paper on "Sunday Labour in Gas-Works," and Mr. George Livesey one on "Is the Reduction of the Sulphur Compounds Worth the Cost and Trouble it Entails?" Well, the works themselves were very different in those days from the works they had seen that morning. Before the meeting to which he had just referred, two articles appeared in the "GAS JOURNAL" describing the Beckton Gas-Works; and the writer was evidently very much impressed. He referred to them as a "mammoth works," which put out a lot of gas at that time even—21 million c.ft. per day. But he waxed quite eloquent on various subjects. "The extreme cleanliness of the works." Well, this was true to-day ["Hear, hear"]; but Mr. Leech must not flatter himself too much. He (the speaker) said "to-day." [Laughter.] The writer of the article remarked also upon the "absence of noise." Well, that was not true then, and it was not true to-day either. But the writer really became most eloquent when he talked about the general appearance of the works. He must read this passage from the article, which he was sure would be of interest to them: "The elevations of the retort-houses have an elegant appearance"—note this touch—"which has been acquired at a nominal extra cost, by excellent design, and a skilful application of small portions of terra cotta and red bricks; and the same style of elegance and neatness pervades the whole of the buildings." Much had happened since those days. Now Beckton was capable of manufacturing in one day no less than 93 million c.ft. of gas, and was capable of unloading 12,000 tons of coal a day; while there were 50 miles of railway carrying coal and residuals about the works. The shops they had seen for themselves; and they knew what they were. It was a noteworthy fact that the works were laid out by Mr. F. J. Evans—Mr. G. C. Trewby was the Resident Engineer—in such a manner that they were capable of developing from a 21 million c.ft. to a 93 million c.ft. works without any serious alteration in the plant and lay-out. Even now they were still making gas—and large quantities of gas—in the very retort-houses which the elegant writer of the elegant article described as such beautiful ones. The Company had grown in every direction; and he did not propose, as they had already heard a paper by Mr. Leech on the works, to take-up any more time on this subject. But he wanted just to say one other word—that the Gas Light and Coke Company was the oldest Gas Company in the world. She was really the mother of all other gas companies. She was now 110 years old, having been born in 1812, and was still very hearty and well, and still growing. Up to date this year, the Company had sent out more gas than they had ever done before in the history of the undertaking. He mentioned this fact, because he thought it was symbolic of the great industry which they all had the honour to serve. They had had many bad half-hours in the industry. They had seen electricity rise up and threaten them; but they were still flourishing, and still ready to go on. He thought that the long life and prosperity of the Gas Light and Coke Company might be taken as a good omen for the future of the industry generally.

They had also present with them that day, he was happy to say, the Institution of French Gas Engineers. [Applause.] He had originally intended to make remarks to them in their own language, but had been deterred that morning by someone saying that Scotch French was the most beautiful thing he had ever heard in his life. *Après ça, c'est impossible.* However, he did claim that, being a Scotsman, he had a special right to propose the toast of "The Society of French Gas Engineers," because long before ever England thought of cultivating the friendship of France, the Scotch were hand in glove with her—much, he might say, to the detriment of England in those days. For years there was an alliance between Scotland and France; and he was not perhaps painting in colours too strong when he supposed that it might be the large influx of his brethren from the North to the South that had paved the way for the *Entente Cordiale* which they now enjoyed. To be serious, these two great countries were bound together now by inseparable bonds. ["Hear, hear."] They had sanctified the alliance by shedding their blood together on the battlefield; and his own Company did their little bit in the war. They sent of their sons 5000 to fight their battles and the battles of France all over the world; and 500 of these brave fellows never came back, but died for England and for France. He had been much touched that day by the fine thought which had led their friends from France to lay a beautiful wreath on the war memorial which had been erected on those works. General political alliances and conferences of politicians no doubt did good; but he believed it was only by working together in business

and by meeting together at gatherings such as this that they would really get the one nation thoroughly to understand the other. Newspapers could not make real *Ententes Cordiales*; but if those who met together in these conferences went away as missionaries to plead for this alliance, which had been sealed by the shedding of so much blood by both countries, they would be doing good work for the peace of the world.

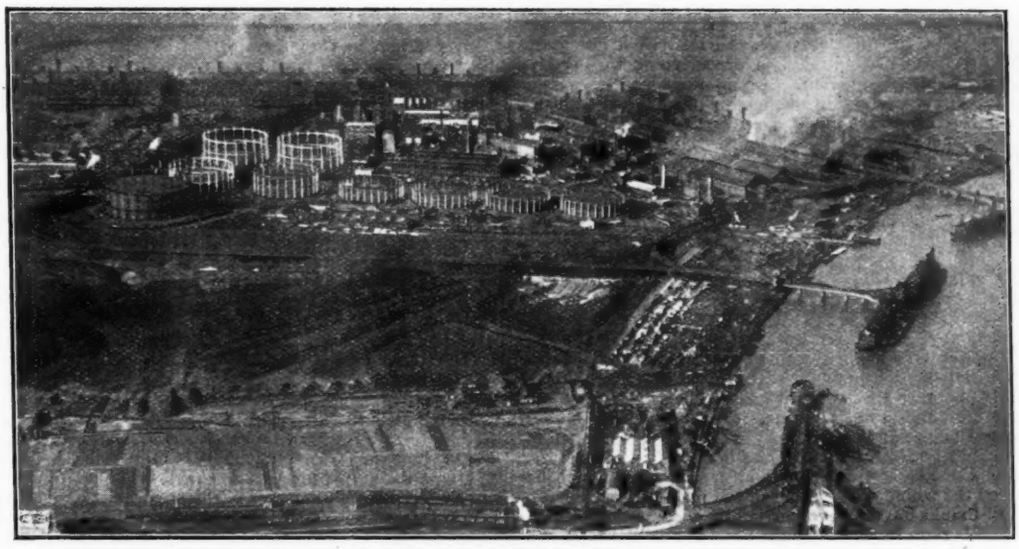
Besides the two great Institutions to which he had referred, they had with them many distinguished guests. He could not enumerate all their names, but felt that he must mention one or two. There was Mr. H. C. Honey, the Director of Gas Administration of the Board of Trade. They were very glad to find that from his serious duties he had been able to snatch a few minutes to come and grace them with his presence. They had also the oldest engineer in the country, he believed, who was at the present moment at work, in their friend Mr. Harry Jones. He felt that he had already taken up far too much of their time; but in conclusion he would just like to say once more how welcome they were, and to express the hope that it would not be so long before they honoured the Company again with their presence at Beckton.

A Visit to Paris.

M. R. ELLISSEN (who spoke in French, which was afterwards translated by M. H. J. Ellissen) said he was delighted to have the opportunity of thanking Mr. Milne Watson for his toast of "The French Technical Gas Society," in the company of their numerous colleagues of the Institution of Gas Engineers, with whom it had been so great a pleasure to mingle during the visit to these fine works. By this visit they had been able to learn more of what they had known a little about already—the technical and moral importance to the gas engineers of England of all that was done at Beckton. The Company's activity and their extensive field of action enabled them to create masterpieces in the gas industry which inspired not only the Company's fellow countrymen, but all the gas engineers in Europe. After their visit, they would take back with them to France the most happy remembrance, not only of what they had seen, but of the manner in which they had seen it. They had found themselves face to face with an undertaking which was absolutely unique for Frenchmen. They had been so good as to promise his colleague M. Laurain to devote some of the short time that they would have at disposal to a visit to the works of the Société du Gaz de Paris, of which there were present that day four Directors and also the Technical Manager. During that visit, they would be cared for and entertained by the Managing-Director, M. Rouland; but they would not find in Paris the unique installations which solved at Beckton in a different way the problem of supplying a large town, and which made the visit here particularly attractive. Nor did the visitors forget that they had had the good fortune to find in Mr. Milne Watson the President of the National Gas Council, who had informed them on the previous day in such an excellent manner of the part enacted by that Council. They in France realized the importance of this organization, judging by the work of the corresponding body in France—Le Syndicat Professionnel de l'Industrie du Gaz—which was presided over by his colleague and friend M. R. d'Estape, Vice-President of the Société Technique. He (the speaker) felt assured he would not be contradicted by anybody—and least of all by his English colleagues—when he asserted that the National Gas Council owed a great deal to its President. To realize this, it was sufficient to have had the pleasure of being at Mr. Milne Watson's side for a few minutes on the previous afternoon, and as he was that morning—even more pleasantly, if possible. Thus it was that he had been able to learn the secret of the power and prestige of the National Gas Council, to which Mr. Milne Watson brought his distinction, his high level of thought, his keen reasoning powers, and his sound knowledge. He was glad to have had the opportunity of becoming personally acquainted with Mr. Milne Watson, and to be able here, in the midst of his vast works, to assure him of the gratitude of all the French visitors.

On Behalf of the Institution.

Mr. T. HARDIE said he felt that words were quite inadequate to express the thanks of the Institution to the Governor and Directors of the Gas Light and Coke Company for the manner in which they had been entertained; and such words as he could find were equally inadequate to thank the Governor for the very eloquent terms in which he had proposed this toast. It was more than a compliment to their Chief Engineer or to the President of the Institution of Gas Engineers that they had been entertained in such a manner that day. It indicated that the Company recognized the importance of the Institution and of the work that this body did. ["Hear, hear."] He himself had had the privilege for some years of being a member of the National Gas Council and of the Federation of Gas Employers; and during this time he had admired enormously the work that Mr. Milne Watson did for the benefit of the industry. In fact, the idea he had then formed was that the greater portion of his work was rather for the benefit of the industry as a whole than of the Gas Light and Coke Company in particular. Since, however, he had had the honour of serving under him, he had found that he had been greatly mistaken in regard to this, and that the work which he did for the organizations in which he held such responsible positions was infinitesimal in comparison with the work which he did for his own Company. Really it was not surprising that the Company did recognize the importance of the Institution of Gas Engineers. Mr. Milne Watson himself, owing to his position on those bodies to which reference had already been made, had ample opportunities of learning what the Institution were doing; and, in addition to this, there was on the Board a gentleman who he believed was one of the oldest members of the Institution. He was sure it was Mr. Goulden's great regret that this visit did not take place last year, when he was President. It would have been much more fitting had it done so, because the work which they had seen that day was to a very large extent Mr. Goulden's work. In fact, he (Mr. Hardie) felt himself as though he was rather masquerading in somebody else's clothes. But Mr. Goulden had had, as he himself had also had, the advantage of a staff on the result of whose efforts the visitors, he was sure, would be able to congratulate them after their survey that morning. He could only thank the Chairman once more for the very generous manner in which the Institution had been entertained, and for the kind words that he had used in connection with this toast.



BECKTON FROM THE AIR.

The Visitors.

Sir ARCHIBALD DENNY said they had heard mentioned the names of some of the distinguished guests, for whom he had the honour to reply; and he was at a loss to know quite why he—a minor light—should have been preferred before others. But he was a Scotsman, one of the nation—because they were a nation—which produced a man to whom those present owed so much. He referred to Murdoch. On behalf of the guests, many of whom, like himself, were not gas engineers, he thanked the Governor and the Directors for the princely hospitality they had enjoyed. This hospitality was offered to them by a great Company, a venerable Company, and yet a family concern to a very large extent; for they could not have failed in going round the works to be impressed, as he himself had been, by the very excellent feeling manifested by the employees towards their employers.

["Hear, hear."] He did not wish to repeat what they had all read in the booklets distributed. The particulars there given showed the vastness of the concern; they had actually seen only the fringe of it. Its very vastness made it impossible to see the whole of it in one day. Regarding it in the light of a port, a greater tonnage was dealt with there than by many reasonably important ports throughout the country; and then, what interested him as a shipbuilder, was that they had a fleet of their own steamers—none of them built by his own firm. But that was the Gas Company's fault, and not his. [Laughter.] To give another example of the vastness of the undertaking, he understood that if the retorts employed were put end to end they would reach from London to Watford, a distance of 14 miles. Then those present knew all about speeds. Taking the gas which was sent to London when full delivery was going on, during a dark winter's day with a heavy fog, it would be found that this gas travelled to London in fifteen minutes, or at the rate of 28 miles an hour. In order that they might maintain a regular supply of gas, the Company had storage capacity equal to two-thirds of the daily output. They had heard the Chairman refer to the competition of gas and electricity. Well, he (the speaker) had had a good deal to do with electricity. No works was complete—not even a gas-works—without its electricity station; and there was to his mind absolutely no rivalry whatever between the industries. They should work hand in hand, for both were required in all industries. They were deeply grateful to the Governor and the Directors of the Gas Light and Coke Company for all they had done to help forward the industry of this country.

THANKS AND ACKNOWLEDGMENTS.

Mr. J. D. SMITH said he had a pleasant duty to perform before they separated, and that was to ask them all to join with him in thanking the Governor and the Court of Directors of the Gas Light and Coke Company for the opportunity afforded them of inspecting these magnificent works, for the excellent arrangements that had been made for their comfort, and lastly, but not least, for their very generous hospitality. He was going to ask Mr. Jones to support this proposition.

Mr. HARRY JONES, addressing the members of the Institution of Gas Engineers, of which he was an early member, and his friends of the Société Technique, said he rose with great pleasure to second the resolution. He was sure they would not like to leave the marquee without giving expression by their acclamations to the feelings which must have been inspired in the hearts of all of them by the generosity—he might say the superb generosity and liberality—of the entertainment. This generosity had received encomiums from his French friends on either side, who had marvelled at the manner in which the wants of some 600 guests had been ministered to. Those who knew Mr. Milne Watson and had watched his work were aware that he did everything thoroughly. It was the custom of Mr. Milne Watson to do things royally and well. He represented a Company that was almost royal—it was originally the Chartered Company. He (Mr. Jones) believed he was the oldest member practising in gas engineering in England now—though there might be older ones in France, of which fact he had no knowledge—and he was very glad to bear testimony to the fine work that Mr. Milne Watson had done in the chair of the National Gas Council, and to the delightful manner in which he had conducted the whole of the proceedings that day.

The vote of thanks having been carried by acclamation,

Mr. MILNE WATSON said he thanked Sir Archibald Denny, Mr. Smith, and Mr. Jones for the more than kind words in which they had referred to the Court of Directors of the Gas Light and Coke Company and himself. All had been delighted to do what they could; and their best thanks were that the visitors had enjoyed themselves. He would like to say one word more. They as a Board of Directors could not hope to succeed in their great task without the efficient help of the staff and co-partners. ["Hear, hear."] When speaking a few minutes ago, he had referred to a period nearly fifty years ago, when Mr. (as he then was) Corbet Woodall was advocating the reduction of Sunday labour. Underneath this was a great idea, and that was the welfare of the workmen; and the idea which was forming in that great man's mind at that time found ultimate expression in their co-partnership. The Company had 10,000 most loyal co-partner employees, holding over £250,000 of the Company's stock—an amount which was growing year by year—and he said that, without their loyal work and help, the Company could not possibly be in the position it occupied to-day. He would also refer specially to what was being done at that particular works by Mr. Leech and Mr. Hutchence and the other members of the staff; and he could not pass on, of course, without mentioning the name of their late great Chief Engineer, Mr. Thomas Goulden, on whose broad shoulders had fallen for many years the task of directing the Company's technical work. They had been fortunate in finding a man after their own heart, Mr. Thomas Hardie, to succeed him in this great work. They were satisfied that in him they had secured a splendid successor, and that the future of the technical work of the Company was assured. He again thanked them.

A photograph taken of the guests while seated in the marquee will be found on p. 881.

Motor coaches were in waiting to take the visitors back to London; and it is safe to say that all left with happy impressions of their reception which will remain long in memory.

THE BECKTON WORKS.

[From a booklet prepared by the Gas Light and Coke Company for the occasion.]

The total quantity of gas produced by the Company during 1921 was 33,444 million c.ft., of which 15,785 millions were manufactured at the Beckton works. The works are situated immediately east of the Royal Albert Docks, with a frontage of about 2500 ft. abutting on to the northern bank of the River Thames. The whole of the Company's Beckton property extends to an area of 475 acres; the gas-works occupying about 234 acres. The first pile of the river wall of the new works was driven in November, 1868, by Mr. Simon Adams Beck, the then Governor of the Chartered Company, in honour of whom the locality was named "Beck Town." Gas was first made at Beckton on Nov. 25, 1870.

Beckton may appear a little remote from London—it is seven miles from the Tower of London as the crow flies—but it is not too far off to avoid being built up to by the ever-growing Greater London. The position of the works was so arranged as to ensure the cheapest access for the vast quantities of coal, the raw material of gas manufacture. Such a position in the case of Beckton is amply secured; and at its two piers jutting out into the river, colliers of the largest size can moor, while their cargoes are rapidly cleared by hydraulic cranes. The disposal of residuals—tar products, and sulphate of ammonia especially, as well as of a large proportion of the coke made at Beckton—is all facilitated by free access to the river.

The site of the works lies in the Essex marshes, some 5 to 8 ft. below the level of Trinity high water. The subsoil underlying the whole of the area in the district is one offering singular difficulties to the engineer in the putting-in of foundations for large buildings, and it is to the credit of those in charge of the original construction of the Beckton works that the imposing buildings they erected stand as solidly to-day as when first built.

In addition to the advantage of extensive river frontage, the Beckton works are in connection with the Great Eastern Railway system by a branch joining-up with the London—North Woolwich line at Custom House, Albert Docks. Direct communication is by the Beckton Road, some three miles long, which the Company constructed, cutting into the London—Barking Road at Canning Town. In the subsoil of this road are laid the two 48-in. diameter cast-iron mains through which the gas made at Beckton travels westward towards the centre of distribution.

The buildings and plant at Beckton, including the larger mains, are either carried on concrete piers built-up from the ballast, some 25 ft. to 30 ft. below the made-up ground level, or on timber or concrete piles driven into the ballast stratum. Some of the lighter structures are supported on ferro-concrete rafts laid on the marsh level.

The greater part of the coal carbonized at Beckton is brought-up by steam colliers of from 1000 to 4500 tons capacity, and is unloaded at the upper of the two "T" shaped piers, which extend into the river some 400 ft. at a level of about 20 ft. above the ground on which the works stand. No. 2 pier, completed in 1895, is now used principally for unloading coal; the original pier (No. 1) being used for the loading in craft of coke, pitch, sulphate of ammonia, and other bye-products. The coal-unloading plant on No. 2 pier consists of twelve hydraulic cranes worked at 750 lbs. pressure. These cranes are fitted with 1-ton grabs, and have derricking jibs, by means of which the grabs can be swung to any position in the ships' holds. About one minute is taken to complete the cycle of movement—lowering, raising, slewing, and depositing into wagons. The average capacity is 50 tons of coal per crane per hour. The total capacity of the pier with three berths working is about 12,000 tons per diem. The coal wagons used are of about 5 tons capacity each, fitted with bottom discharging doors. The maximum quantity of coal unloaded during any single year (1913) was 1,528,000 tons.

Situated midway between the two piers is the hydraulic power house surmounted by a clock tower. Hydraulic power for operating the cranes on the two piers is provided by means of five compound pumping-engines, two of 125 H.P. each, and three of 200 H.P., pumping 320 gallons per minute each. The steam pressure is 130 lbs., and water pressure 750 lbs. The piers are connected to an elevated railway built between the two main rows of retort-houses, extended by viaducts situated round the outer edge of the works. The whole of the ground space under these viaducts is used for coal storage.

There are fourteen retort-houses, twelve of them being built in two parallel lines on either side of the viaduct running inland from No. 1 pier, forming a bend similar in shape to the half of a horse-shoe; the original intention having been to complete the horse-shoe to No. 2 pier and instal the remainder of the plant within it. On account of the excessive amount of haulage of material so far inland, however, the original design of the works was departed from, and Nos. 13 and 14 retort-houses were built inside the horse-shoe, and near the river.

Each retort-house at Beckton constitutes the nucleus of a complete gas-works, having its own exhausting, condensing, purifying, and measuring apparatus. The original plant has been augmented from time to time, in order to deal with the increased production of the individual retort-houses subsequent to reconstruction. The various sets of plant are, however, mostly interchangeable. The retort-houses were originally designed for retorts worked by manual labour, but all are now

operated by machinery, the first of which was introduced in 1884. Most of the retort-houses have been twice reconstructed, and their gas-making capacity more than doubled.

The fourteen retort-houses, if placed end to end, would extend nearly 1½ miles. Including No. 6 retort-house (in process of reconstruction), they contain 4146 horizontal through retorts, all of 20 ft. length, except in No. 7 retort-house, where they are 23 ft. long. Including No. 6 retort-house, the total nominal maximum capacity of the works for coal-gas production will be 66 million c.ft. per diem.

The retorts in Nos. 1 and 12 retort-houses are operated by Fiddes-Aldridge electrically driven stoking machines, discharging and charging in one operation. Nos. 2, 3, 4, 5, and 8 retort-houses were fitted on reconstruction with West's compressed-air machines, consisting in each case of a charging machine and a separate pusher discharger; but the charging machines have now been converted to the De Brouwer projector type. Nos. 10, 11, 13, and 14 retort-houses are fitted with Arrol-Foulis hydraulic machinery. Drake's electrically driven combined stoking machines have been recently installed in Nos. 7 and 9 retort-houses.

With the exception of Nos. 10, 13, and 14, all retort-houses are now fitted with mechanical appliances for handling coke. In No. 7 retort-house (last reconstructed) there is a transporter by means of which the coke is transferred from the retorts to a reinforced concrete coke bench, where it is quenched, and from which it is removed by telpher to the storage hoppers. The remainder of the installations consists of hot-coke conveyors, whereon the quenching is carried out, supplemented by inclined and distributing conveyors to the coke hoppers. The whole of the retorts at Beckton are of the horizontal type.

The extraction of cyanogen is carried out in rotary washers by means of ferrous sulphate solution; a portion of the ammonia being simultaneously removed. Rotary washers, which are gradually replacing the tower scrubbers originally built, are in use for the recovery of the balance of the ammonia.

For the removal of the sulphuretted hydrogen there are twelve sets of purifiers, each consisting of eight boxes; the purifying material being oxide of iron. Two additional sets of purifiers have recently been erected in reinforced concrete, each consisting of four boxes worked in rotation, followed by check vessels. On the outlet of each set of purifiers is fitted a suitable station-meter, two of these having a capacity of 300,000 c.ft. per hour each.

In addition to the plant for the manufacture of coal gas, there is carburetted water-gas plant, which, with two blue-gas sets, is of a total daily productive capacity of 27 million c.ft., bringing the total daily capacity of the works to 93 million c.ft. The original plant, which has now been demolished, consisted of twelve single-generator sets, each capable of producing about 1½ million c.ft. of carburetted water gas per diem. The first of these sets was designed and operated by the works staff; and they were the earliest installations in this country.

The whole plant has been remodelled within the last few years; and at the present time there are nine sets in all. Seven of the sets are for the manufacture of carburetted water gas. Each set consists of twin generators, followed by carburettor and superheater for the gasification of oil. Each set is capable of producing upwards of 3 million c.ft. per diem. The eighth and ninth sets are for the production of blue water gas, and are built with twin generators, followed by waste-heat boilers.

All the valves are operated by hydraulic power, and controlled by hand levers. The working cycles of all sets are synchronized by electric clocks controlled by a master clock.

The coke used in this plant is brought from the retort-houses in side-tip wagons, afterwards being elevated and conveyed by electric telpher to the storage hoppers from which the generators are supplied with fuel. From these hoppers, which are mounted above the operating stage, coke is fed into the generators over special screens for the removal of breeze, which is tipped direct to the adjoining boiler-house.

The "blowing" plant for this installation consists of Rateau fans, each driven by a De Laval turbine of 110 H.P. These fans are mounted on the upper floor of the power-house; while on the ground floor are fixed the necessary exhausters for the gas, and pumps for the circulation of water, oil, &c.

Two holders, each of 1 million c.ft. capacity, are used as relief holders in connection with the inlet of the exhausters. The carburetted water gas is cooled in a large atmospheric condenser of the usual Beckton type, which supplements water-cooled condensers, through which softened water is passed, before being utilized for boiler-feed purposes, from an overhead storage tank holding 40,000 gallons.

The boiler-house contains four pairs of Babcock and Wilcox boilers, each evaporating 1000 gallons per hour, hand-fired, and fitted with forced draught for burning breeze. Two additional pairs of Babcock and Wilcox boilers, each of 1400 gallons per hour capacity, recently installed, are fitted with mechanical grates designed to burn fine breeze. There is a subway for the conveyance of ash to a telpher pit, whence it is raised by a telpher grab and dumped into an overhead hopper for loading into trucks. This refuse, as also the furnace ashes made in the retort-houses, is removed and treated by washing in "Blackett" cylinders for the recovery of the unburnt fuel; its separation from the clinker being completely effected. The same telpher grab conveys breeze for fuel into overhead hoppers in the boiler-house.

A reinforced concrete water-softening plant, of the lime-soda type, is installed in connection with these boilers. It is to the design of the Paterson Engineering Company, and of 30,000 gallons per hour maximum capacity, with three hours' sedimentation. After being separately metered and tested, the carburetted water-gas mixes with the coal gas on the inlet of the holders.

The pumping plant, by means of which the whole of the gas produced at Beckton is delivered to the Company's distribution area, is installed in Nos. 1 and 2 pumping-houses, in the first of which the present capacity, with four pairs of exhausters, is 2,800,000 c.ft. per hour. Two sets of Reavell turbo blowers, each with a capacity of 1½ million c.ft. per hour, have been installed in place of one pair of 250,000 c.ft. exhausters recently dismantled. It is proposed to duplicate these blowers in the near future.

The maximum pressure at which gas is normally pumped is 48 in.; but the turbo blowers recently installed are designed to pump against a higher pressure—namely, 80 in. (water column); and the combined capacity of three sets will be adequate to the normal winter load. The turbines are designed to work with condensers; and in connection therewith a cooling tower has been erected.

In No. 2 pumping-house there are two further pairs of exhausters, with a combined capacity of 1,450,000 c.ft. per hour. These exhausters are of modern type, and can, if necessary, work with the turbines against the high pressure. As the gas is pumped into the two 48 in. diameter mains, it receives anti-naphthalene treatment by petroleum oil, vaporized by steam heat or atomized by compressed gas.

During the year 1921, 1,254,800 tons of coal were carbonized at Beckton; and the highest actual make of gas for one day, up to the present time, was 75,985,000 c.ft. on Dec. 17, 1920.

There are upwards of 50 miles of standard gauge railway on the works, the principal running roads being worked on the "block" system. The rolling stock comprises some 1400 wagons of various types and 40 locomotives.

To provide electrical power for the stoking machines in Nos. 1, 9, and 12 retort-houses, motors for coke handling plant, breeze washing and screening, telphers, water filtration plant, &c., operated by 110 motors, there are in all three generators of 45 KW. capacity each, three of 80 KW. each, and one of 112 KW., giving an output of 487 KW. (D.C.). This plant is connected to the electric generators at No. 12 retort-house engine-room, the output of which is 130 KW. The whole of the electric generators are driven by direct-coupled gas-engines.

An auxiliary power-house, carried out in ferro-concrete, has recently been erected to contain three generators of 200 KW. each, direct-coupled to compound vertical steam-engines. These are supplied by surplus steam power from the breeze-burning boilers at the carburetted water-gas plant. The total electric generating power is equal to approximately 1630 H.P.

For the upkeep of plant, there are extensive repair workshops, including the boiler-shop, equipped with pneumatic tools, acetylene burning and welding plant, &c., in which some 80 men and boys are employed in the repair of stationary and locomotive boilers, and work of similar nature. Coppersmiths' and tinsmiths' shops are also in full use.

The erecting and machine shops are extensive, and employ some 100 mechanics. There are 40 lathes, planing, and shaping machines, radial arm and other drilling machines, which are kept fully occupied in repairs to locomotives, pumps, and machinery. Two of the locomotives now in use were built here. There is also an iron foundry, capable of producing some 50 tons of castings per month, and a pattern shop in connection therewith.

Two large shops and a repairing yard are allocated to the blacksmiths' department, containing 36 forges, five steam hammers, punching and shearing machinery, cold saws, &c. In an adjacent large shop repiars to iron wagons and coal-raising grabs are carried out. There is an electrical shop for the use of the special staff dealing with the maintenance of electric motors, signalling apparatus, telephones, &c.

The engineering shops previously referred to have been in use, with occasional extensions, since work was first started at Beckton. The extent to which machinery and mechanical appliances are now employed is such as to render the older buildings quite inadequate to present needs. The repair work of the station is now being concentrated in a large ferro-concrete workshop, 384 ft. by 122 ft., which, besides accommodating the bulk of the mechanical engineering of the station, is amply fitted with storage accommodation and offices for the Superintending Mechanical Engineer and his drawing office staff.

On the western side of the works is the wood-working department, which includes the carpenters' shop and permanent-way department. Here wooden wagons, including the permanent-way wagons, used in the coke trade, are built and repaired. This department also deals with the maintenance of the 50 miles of works railroads.

Books and Pamphlets.

A copy of the "Bulletin" (No. 2) of the Semet-Solvay and Piette Coke-Oven Company, Ltd., of Sheffield, has been received. There are several interesting short articles in its pages, among which we notice one on "Sulphate of Ammonia, Neutral and Dry," reviewing the methods that are practiced.

From the "B.C.G.A." we have to acknowledge the June issue of the "Bulletin;" also No. 100 of "A Thousand and One Uses of Gas," in which illumination of printing works is dealt with.

GENERAL REPORT.

THE Annual General Meeting of the Institution was held on Tuesday, Wednesday, and Thursday of last week, June 20 to 22, at the Institution of Electrical Engineers, Victoria Embankment, London—Mr. THOMAS HARDIE, M.Inst.C.E. (the Chief Engineer of the Gas Light and Coke Company), presiding.

The President's Welcome.

The PRESIDENT: I am very pleased to see so many present to-day. I give you a hearty welcome, and hope we shall have an enjoyable and successful meeting.

Confirmation of Minutes.

The PRESIDENT: The first item on the agenda is the minutes of the last general meeting. These have been printed; and I now submit them for your confirmation.

They were confirmed.

Appointment of Scrutineers.

The PRESIDENT: The next business is the appointment of Scrutineers for the examination of the balloting-lists for the election of officers and Council, members, and associate members. I suggest the names of Mr. S. J. Ingram and Mr. W. Rogerson.

This was agreed to, on the proposition of Mr. W. C. JACKSON (Neath).

The Presidential Address.

The PRESIDENT then rose, amid loud applause, to deliver his address, which will be found on p. 794.

Vote of Thanks to the President.

At the conclusion of the address,

Mr. CHARLES WOOD (Bradford) said: When last year I got away from the Council and the platform of this Institution, I certainly thought I might keep a little bit in the background, and criticize the work of my successors. On this occasion, however, I have not got up to criticize, but to propose a vote of thanks to our President for his magnificent address. Some of us, when Mr. Hardie came to London a little while ago, thought that perhaps his new duties with the Gas Light and Coke Company might interfere in some way with his duties as President of the Institution. However, I am sure, from the way in which everybody here has listened to the address this morning, that they will agree it has suffered in no way from Mr. Hardie's having come to London. His friends—especially in the North—are pleased he has come to London, where we know he will do credit both to himself and to the great gas community in whose service he is engaged. There is no particular part of the address that can be picked out for special comment. It is full of useful, well-thought-out information, and suggestions that will be most valuable to every member, and particularly to the younger men of the profession; and I am sure you will all join in passing a very hearty vote of thanks to the President for his address.

Mr. THOMAS GOULDEN (London): It gives me very great pleasure indeed to second this vote of thanks to our President for his exceedingly interesting address. I do not think I can recollect an address of such general interest. He has left untouched barely a point in the working of our industry, and there is no point on which he has touched on which he has not given us food for very careful thought, to our ultimate advantage when we go home from this meeting. I, like Mr. Wood, have really wondered how Mr. Hardie, with the close application that I know he gives to his particular work here as Chief Engineer of the Gas Light and Coke Company, has managed to find the time to write so finished and so instructive an address. I was going to sympathize with Mr. Hardie's friends in the North at his having come South; but since I hear they are all pleased that he has come South, it is quite evident that my sympathy would be misplaced. [Laughter.] I may, however, be allowed to congratulate ourselves here in London at his coming among us. ["Hear, hear."] I do that very heartily. Good as was the opinion I had of Mr. Hardie, and of his many qualities, before he came South, since he has done so I have learned to esteem him very much more. But the subject just now is the address; and I am sure it is full of matter. It is not permitted to discuss the address; but the general up-to-dateness of it has struck me most particularly. There are many novel features in it; and I am glad to hear from our President's lips his considered opinion that the last change—the change to charging for gas by the therm—is meeting with his approval. It certainly meets with mine; and I believe it will ultimately tend to the benefit, not only of the consumers, but of the whole of the industry. He has touched upon one point that is certainly very close to my heart—and this is the coming into closer touch of employers and employed. There can be no doubt that there is no more pressing subject at this time which we should take to heart and put into practical effect than the spreading of knowledge among workmen of the business in which they are engaged. No man is a law unto himself; and it is the spread of real knowledge on the part of both employers and employed, of the details of each other's working—the sympathy of one class with the other—that will have the most beneficial effects upon industry generally. It is the great necessity of the time. I have got rather away from my particular point, which is to second the vote of thanks which Mr. Wood has proposed to the President for his address. I do so with the greatest earnestness; and I feel that not only is our President to be congratulated on the address he has given us, but that the Institution itself is very sincerely to be congratulated on having such a practical and thoroughly good address in every way. It has given us much food for thought. The President has touched pretty well every point we can possibly think of at the present time. He has looked ahead; and we shall go home and study the address, and, I am sure, derive great benefit from it.

The vote of thanks was accorded with acclamation.

The PRESIDENT: I thank the mover and seconder very much for their kind words; and you, gentlemen, I thank for the cordial way in which you have received the vote. I am sorry that the address has taken rather longer to read than I expected it would; and it has left us less time for other work, which is more important.

The Annual Report.

[See "JOURNAL" for June 7, p. 556.]

The PRESIDENT: The next item on the agenda is the adoption of the annual report of the Council; and I beg to move that the report, which has been circulated, be adopted.

Removals by Death.

In doing so, I should like to refer specially to the loss which the Institution has sustained in the death of the 16 members whose names are recorded in the report. No less than four of these were honorary members; and among these four were two French engineers, of whom M. Ellissen was one of the fathers of the Société Technique, and father of the present President, whom we hope to have the pleasure of welcoming to our meeting on Thursday. The other two honorary members—Mr. Thomas Duxbury and Mr. John West—were both prominent in gas matters long before most of us can remember. In that interesting period when the old Gas Institute was being re-organized, Mr. Duxbury was very active. To Mr. John West it is impossible to estimate how much the industry owes. He was an unwearied worker, and investigator of unusual thoroughness, and of deserved success, a man of fine character, and a great personality. Since the writing of the report, we have lost another very old member, in the person of Mr. George R. Hislop, who was much loved in Scotland, and admired by us all. Only last Sunday the death took place of Mr. Walter King. As Editor of the "GAS JOURNAL," he has wielded a great power in the interests of our industry.

He was a man of sound judgment, a clever analyst of both words and figures, quick to separate the sound from the base; and he never failed to keep before us the matters so helpful to our progress. He was a friend indeed to many of us; and there are few in this room who do not feel his death as a personal loss. I am sure it would be your wish that we should send from this meeting an expression of our regret, our respect for him, and our sincere sympathy with his family in their trouble. I ask you to rise, as a mark of our esteem for those I have mentioned and the others referred to in the report, among whom is the very revered name of Sir Daniel Ford Goddard.

The members stood in silence for a brief space.

Mr. LAURIE TREWBY (Mill Hill): I have much pleasure in seconding the adoption of the report.

Mr. GEORGE HELPS (Nuneaton): Before the resolution for the adoption of the report is put, I should like to say a few words. I may find it necessary to move, as an amendment, that this report be referred back. If I do so, it does not necessarily follow that I shall do it in any offensive way. I cannot attend a meeting like this, and listen to all the various ideas that are expounded here with regard to the main matter of cheap gas, without taking the opportunity (which I am afforded this morning) to call your attention to the fact that in this report there is not a single line pointing to any effort being made to let the consumer get the gas he is entitled to for his money. All sorts of statements have been made at these meetings in the past, and are made to-day, about the manufacture and distribution of gas; but all these remarks are made on the experience of the past, and not on the present. Of what use is it for a man to get up and say: "We must send out gas of 500 B.Th.U.," if that man has had no other experience? If he had sent out a lower quality of gas, he would not make the statement that 500 B.Th.U. gas was the only quality gas to send out. Since the war, and within the last year or two, we have had placed on the Statute Book the new Gas Regulation Act, which allows us to distribute gas of any quality. What have we done to exercise the powers of that Act? Nothing at all! I stand up here this morning and say this definitely, and base it on my own actual work—that it is within the possibility of every representative of a gas undertaking here from his particular works to send out from two to three times the therms he is sending out to the consumers for the money they are being charged to-day. You may say: "This is all nonsense," as often as you like. It is easy to say that; but why don't you get down to it, and say that the point of view from which we have for years been accustomed to discuss the matter of gas is wrong?

The PRESIDENT: Are you speaking of the report? I think you are rather wandering. Please keep to the report.

Mr. HELPS: My point is that in the report the matter of cheap gas is not dealt with, and I say seriously that this meeting, if it pretends to represent the gas industry, and at the same time the gas consumer, trying to associate fairly one with the other, should take steps to deal with the matter. I move, as an amendment, that the report be referred back, with a view to steps being taken to inquire into what means might be adopted to supply the consumer with cheaper gas. I hope I shall find someone to second it.

There was no seconder; and the report as originally presented was unanimously adopted.

Aeration in Atmospheric Burners.

The PRESIDENT: I will now call upon Prof. Cobb to make a statement with reference to research on aeration in atmospheric burners.

Prof. J. W. COBB then made his statement, which will be found on p. 799.

The PRESIDENT: You have heard the statement by Prof. Cobb with regard to the position of this research work. I am sure that what he has said will make us look forward with still greater interest to the report which we may hope to have next year on this interesting subject. I do not think really that there should be any detailed discussion upon what has been said to-day; but if anybody desires to ask any questions of Prof. Cobb, I am sure he will be pleased to answer them.

No questions were asked.

Seventh Report of the Gas Investigation Committee.

The PRESIDENT: As there are no questions, we will proceed to the next item, which is the Seventh Report of the Gas Investigation Committee—"Carburetted Water-Gas Plant with Waste-Heat Boiler." I will ask Prof. Cobb to introduce this Report.

Prof. COBB introduced the report—see p. 800.

The Liberation of Nitrogen and Sulphur from Coal Coke as Ammonia.

The PRESIDENT: The first item on the agenda for this afternoon is the report of the Institution Gas Research Fellowship, by Dr. A. C. Monkhouse and Prof. J. W. Cobb, Perhaps Prof. Cobb will introduce this report.

Prof. COBB then introduced the report, which will be found on p. 828.

Life of Gas-Meters Committee.

The PRESIDENT: We now come to the report of the Life of Gas-Meters Joint Committee. I will call upon Mr. Parkinson to introduce this.

Mr. B. R. PARKINSON then presented the report [see p. 834], from which he read some extracts.

Refractory Materials Research Committee.

The PRESIDENT: I will now call upon Mr. Broadberry (the Chairman) to submit the report of the Refractory Materials Research Committee.

Mr. A. E. BROADBERRY (Tottenham) then introduced the report—see p. 840.

The President for the Next Year.

The PRESIDENT: I have to announce the result of the ballot for Officers and Members of Council for 1922. The President is Mr. James D. Smith, of Belfast. [Applause.]

Mr. JAMES D. SMITH: I thank you for the great honour you have conferred upon me in appointing me President for the ensuing year. I shall always keep in mind the long list of Past-Presidents, and keep their example before me; and I hope to merit your confidence as President of the Institution. I thank you.

New Officers.

President.—Mr. James D. Smith, of Belfast.

Vice-President.—Mr. James Paterson, M.A., of Cheltenham.

[The Vice-President remaining in office is Mr. Samuel Tagg, of Preston.]

New Ordinary Members of Council.—Mr. J. E. Blundell, of Carlisle; Mr. H. D. Madden, of Cardiff; Mr. W. J. Smith, of Bolton; and Mr. J. W. Whimster, of Bath.

Auditors.—Mr. S. Y. Shoubridge, of Eastbourne, and Messrs. Wood, Drew, and Co.

Hon. Secretary.—Mr. W. E. Price, of Hampton Wick.

Mr. W. E. PRICE: It is very good of you to re-elect me Hon. Secretary. I am beginning to think it is time you turned your attention to someone else. [Cries of "No."] I do not want to be greedy; but so long as you say you would like me to be here, I am your servant. I thank you.

The PRESIDENT: Mr. Price has a long time to go in those circumstances.

The Roll of the Institution.

The roll of the Institution was increased by the addition of the following names:

MEMBERS.

Barratt, T. W., Engineer and Manager, Gas-Works, Morecambe.

Beaumont, T. H., Engineer and Manager, Gas-Works, Horley.

Booth, J. H., Engineer and Manager, Gas-Works, Poulton-le-Fylde.

Bridge, J., Engineer and General Manager, Gas-Works, Elland.

Buckley, J. E., Engineer, Manager, and Secretary, Gas-Works, Marsden, Yorks.
Cartlidge, W. A., Engineer and Manager, Gas-Works, Congleton.
Clark, R. J. H., Chief Assistant Engineer, Gas-Works, Plymouth.
Cooper, J. E. L., Engineer, Manager, and Secretary, Yeadon and Guiseley Gas Company.
Cutler, A. E., Gas-Works Engineer and Manager, Edison Swan Electric Company, Ponders End, Middlesex.
Dahlander, R., Director and General Manager, Gas-Works, Stockholm.
Duxbury, H., Engineer and Manager, Gas-Works, Llandudno.
Godwin, C. L., Engineer and Manager, Gas-Works, Woodbridge, Suffolk.
Hamilton, G., Engineer and Manager, Gas-Works, Barrhead.
Hands, S., Engineer and Manager, Gas-Works, Sleaford.
Hyde, J. B., Engineer, Manager, and Secretary, Gas-Works, Hawkhurst.
Lawson, J. P., Manager, Gas-Works, Whitchurch, Salop.
Longbotham, C. R., Engineer and Manager, Gas-Works, St. Albans.
Matthews, F., Chief Engineering Assistant, Gas-Works, Bournemouth.
Nairne, U. O. S., Works Manager and Chief Chemist, Gas-Works, Wandsworth, London, S.W.
Needham, R., Manager and Secretary, Gas-Works, Ramsey, Isle of Man.
Parrish, P., Manager of the Chemical Works of the South Metropolitan Gas Company.
Peel, F., Gas and Water Engineer and Manager, Gas-Works, Tyldesley.
Phillips, W., General Manager and Engineer, Gas Works, Luton.
Pilbeam, H. T. W., Gas Engineer, City of Santos Improvements Company, Santos, Brazil.
Porteous, F., Engineer and Manager, Gas-Works, Ware, Herts.
Reid, D. V., Engineer and Manager, Gas-Works, Huntly.
Rendle, C. F. W., Engineer and Manager, Gas-Works, Redditch.
Robb, J., Engineer, Managing Director, and Secretary, Gas-Works, Chepstow.
Roberts, A. R. W., Engineer and Manager, Gas-Works, Hereford.
Robinson, F. C., Assistant Engineer, Hull Station of the British Gas Light Company.
Robinson, G., Engineer and Works Manager, Gas Works, Pinner, Middlesex.
Rooney, P. J., Engineer and Manager, Gas-Works, Strabane, Ireland.
Russell, M., Engineer and Manager, Gas-Works, Elstree.
Shadbolt, E., Manager and Secretary, Gas-Works, Grantham.
Tsukada, S., Superintendent, Gas-Works, Nagoya, Japan.
Wadsworth, H. (formerly a Student), Engineer and Manager, Gas-Works, Knaresborough.
Weyman, G., D.Sc., Chief Chemist, Gas-Works, Newcastle-on-Tyne.
Wise, W. H., Engineer and Manager, Gas-Works, Droitwich.

ASSOCIATE MEMBERS.

Biddulph-Smith, T., F.C.S., Coke-Oven and Bye-Products Works Manager and Chemist, Stocksbridge, Sheffield.
Bullen, A. E., Second Technical Assistant, Gas-Works, Plymouth.
Diamond, G. Le Boutillier (formerly a Student), Engineering Assistant, Gas-Works, Brighton.
Gair, C. J. Dickenson, O.B.E., F.C.S., Works Chemist, South Metropolitan Gas Company, Vauxhall.
Harmes, E. A., Chief Draughtsman, Gas-Works, Brighton.
Hayter, A. H., Assistant Chemist, Gas-Works, Hornsey, N.
Hester, J. D., Assistant Manager, Gas-Works, Ventnor.
Higgs, H. G., Works Chemist, Gas-Works, Salisbury.
Horwood, H. G., Assistant Engineer, Rhymney and Aber Valleys Gas and Water Company.
Ingram, L. Pool, B.Sc. (formerly a Student), Junior Assistant Engineer and Chemist, Gas-Works, Plymouth.
Livesey, D. T., Assistant Engineer, Gas-Works, Stretford.
Macdonald, D. M., Research and Works Chemist, Gas Light and Coke Company, Bromley.
McGilligan, J., Assistant Engineer and Manager, Gas-Works, Middlesbrough.
Savage, W. J., Chemist and Works Assistant, Oriental Gas Company, Calcutta.
Southgate, F., Engineer and Manager, Hythe Works of the Folkestone Gas and Coke Company.
Surman, C. W., Assistant Engineer and Manager, Gas-Works, Rugby.
Symons, F. J. (formerly a Student), Assistant Engineer, Rhymney and Aber Valleys Gas Company, Gas-Works, Bargoed.
Vince, F. H., Resident Works Superintendent, Redheugh Gas-Works, Newcastle-on-Tyne.
Wells, A., Engineer and Manager, Gas-Works, Milton Regis, Kent.
Widlake, H. C., General Engineering and Electrical Assistant, Gas-Works, Plymouth.
Wikner, S. A. W., Manager, Bye-Products Works of the Newcastle and Gateshead Gas Company.

When the Institution meeting was resumed on Wednesday morning, after the Benevolent Fund meeting, the report of which appears on p. 827,

The PRESIDENT said: The first item on the agenda is a paper by Dr. Carpenter, which I will ask him to read.

Some Gas-Burners and a Moral.

Dr. CHARLES CARPENTER then read his paper on "Some Gas-Burners and a Moral," which will be found, with a report of the discussion, on p. 853.

The paper was accompanied by a very interesting display of gas-burners and fittings.

Dr. CARPENTER, by way of introduction to his paper, said: "I ought, perhaps, to make an explanation here. Those who have followed political events closely, as we have all been compelled to do during the last eight or ten years, must have been impressed with the fact that a great many people, even those placed highly as regards the carrying on of the Government of the country, have shown a somewhat remarkable want of knowledge of the elements of history and also of geography. I do not think they need be ashamed of this, because when we leave school we have not an opportunity of keeping up this knowledge. It occurs to me that the same thing may be true of gas; and I think we can better understand the problems of to-day, and the means of solving them, if we remember a little of the history of gas lighting, which, as you know, now extends over a hundred years."

Increasing the Rate of Carbonization.

Dr. GEOFFREY WEYMAN'S paper on "Increasing the Rate of Carbonization," and the discussion [see p. 864], brought the morning's session to a close.

Reconstruction Problems at Beckton.

The PRESIDENT: This happens to be an afternoon when there is a good deal going on in London, and I know some of you are anxious to get away. Though the next paper on the agenda is a difficult one to summarize, I will ask Mr. Leech, if he can, to reduce his remarks to something less than there is in the text, so that we can get on with the discussion promptly.

Mr. W. B. LEECH: It is rather difficult to cut down the paper [see p. 871], but I will do my best.

Greetings from Italy.

The PRESIDENT: We have had a telegram from Rome, from the President of the Italian Institute of Gas Engineers, who says: "Italian gas engineers send to their English colleagues hearty wishes and best friendship on the occasion of their congress." It is very pleasant to receive such a message from our Italian friends, and a suitable reply shall be sent to them.

A Welcome to French Friends.

When the meeting re-assembled on Thursday morning, the members had with them the following representatives of the Société Technique de l'Industrie du Gaz en France, who received the most hearty of welcomes. On the right of Mr. Hardie sat M. R. Ellissen (the President of the Société) and on the left M. R. d'Estape.

LIST OF MEMBERS OF THE SOCIÉTÉ TECHNIQUE VISITING LONDON.

BUREAU.

Ellissen, R., Président de la Société Technique de l'Industrie du Gaz en France, Administrateur-Délégué de la Compagnie Générale du Gaz pour la France et l'Etranger, Administrateur de la Société du Gaz de Paris—24, Boulevard des Capucines, Paris.
d'Estape, R., Vice-Président de la Société Technique de l'Industrie du Gaz en France, Administrateur-Délégué de la Société du Gaz et de l'Electricité de Marseille, Administrateur de la Société du Gaz de Paris—20, Rue de l'Arcade, Paris.

MEMBERS.

d'Aubenton, Ch., Directeur de la Compagnie du Gaz de Lyon —11, Cours de Verdun, Lyon.
Baril, A., Sous-Directeur Technique de la Société d'Eclairage, Chauffage et Force Motrice—180, Avenue du Pont d'Epinay, Gennevilliers (Seine).
Chervet, E., Ingénieur Principal des Usines de la Compagnie du Gaz de Lyon—18, Quai Rambaud, Lyon.
Coudelou, R., Directeur de la Compagnie Européenne du Gaz, Le Havre (Seine Inferieure).
Gardiner, Sir R. S., Administrateur de Compagnies Gazières—39, Lombard Street, Londres.
Laedlein, H., Directeur des Services Techniques de la Société du Gaz de Paris—31, Avenue Trudaine, Paris.
Piaton, R., Ingénieur, Administrateur-Délégué de Compagnies de Gaz—49, Rue de la Bourse, Lyon.

ANCIENS PRÉSIDENTS.

Laurain, H., Ancien Président de la Société Technique de l'Industrie du Gaz en France, Ingénieur-Conseil, Administrateur, Membre du Comité de Direction de la Société du Gaz de Paris—6, Rue Condorcet, Paris.
Ellissen, J., Faisant fonctions de Secrétaire du Comité—24, Boulevard des Capucines, Paris.

MEMBRES SOCIÉTAIRES.

Bazille, A., Ingénieur en Chef et Régisseur des Usines de la Société d'Eclairage, Chauffage et Force Motrice—22, Rue de Calais, Paris.
Bernard, M., Directeur des Usines de Lille de la Compagnie Continentale du Gaz—35, Rue Saint-Sebastien, Lille (Nord).
Berriat, E., Ingénieur, Chef du Service des Canalisations Souterraines à l'Omnium Français des Tubes en Fer et en Acier—14, Rue Angélique Vérien, Neuilly-sur-Seine (Seine).
Bode, E., Secrétaire Général de la "Continental Union Gas Company"—7, Drapers Gardens, London, E.C.
Brille, L., Ingénieur-Conseil des Etablissements Visseaux de Lyon—36, Boulevard Haussmann, Paris.
Capuron, P., Directeur de l'Union Gazière du Sud-Ouest à Bordeaux—110, Rue Judaique, Bordeaux.
Chamon, G., Administrateur de la Société du Gaz de Paris —29, Rue Claude-Vellefaux, Paris.
Cornuault, A., Ingénieur, Sous-Directeur de la Compagnie Anonyme Continentale pour la Fabrication des Compteurs—4, Rue Weber, Paris.
Cros, L., Directeur de la Compagnie Européenne du Gaz à Rouen, Ile Lacroix, Rue Centrale, Rouen.
Descours, G., Propriétaire, Administrateur d'Usines à Gaz —11, Cours de Verdun, Lyon.
Descours, F., Ingénieur A. & M. à la Société Vve. Descours & Fils—11, Cours de Verdun, Lyon.
Dupoy, R., Administrateur-Directeur de la Société Industrielle des Compteurs à Gaz—3, Rue Collange, Levallois-Perret (Seine).
Dupuis, J., Ingénieur à la Compagnie des Forges de Châtillon, Commentry et Neuves-Maisons—102, Boulevard de Courtais, Montlucon (Allier).
Grandpierre, Ch., Ingénieur, Directeur-Commercial Adjoint de la Société Anonyme des Hauts Fourneaux et Fonderies de Pont-à-Mousson—11, Rue Saint-Léon, Nancy (Meurthe et Moselle).
Gregory, P., Directeur aux Entreprises Simon-Carvés—39, Rue de la Boétie, Paris.
Guernut, F., Directeur de l'Usine à Gaz de Boulogne-sur-Mer, Boulogne-sur-Mer (Pas de Calais).
Heeley, G., Administrateur de Compagnies de Gaz—27, Rue Claude-Vellefaux, Paris.
Huon, A., Directeur de la Compagnie Européenne du Gaz, Nantes (Loire Inférieure).
Keclik, Th., Ingénieur, Docteur en Sciences Techniques, Directeur des Services Industriels, Gaz, Eau, Electricité de la Ville de Klatovech (Tchécoslovaquie).
Largeron, A., Ingénieur à la Compagnie Européenne du Gaz —26, Quai de la Somme, Amiens (Somme).
Laurent, J., Directeur de la Compagnie du Gaz de Chambéry (Savoie).
Martial, Ch., Directeur de la Succursale de la Compagnie pour la Fabrication des Compteurs et Matériel d'Usines à Gaz—95-97, Rue Marengo, Marseille.
Martin, A., fils, Ingénieur à la Maison Arthur Martin—45, Rue Ulens, Bruxelles (Belgique).
Martin, M., Industriel—45, Rue Ulens, Bruxelles (Belgique).
Martin, H., Ingénieur au Groupe Piaton—8, Rue Auguste-Comte, Lyon.
Maurin, L., Directeur de l'Usine à Gaz—145, Rue d'Auge, Caen (Calvados).
de Montravel, F., Directeur de la Compagnie du Gaz de Montpellier (Hérault).
Ricart, J., Directeur de la Société Roubaisienne d'Eclairage par le Gaz et l'Electricité—73, Rue d'Alsace, Roubaix (Nord).
Tertre, J., Directeur de l'Usine à Gaz de Saragosse (Espagne).
Van Thourmout, G., Ingénieur, Directeur de la Compagnie du Gaz de la Banlieue de Roubaix, Usine à Gaz de Croix —12, Rue du Pays, Roubaix (Nord).
Verdier, J., Ingénieur à la Société du Gaz de Paris—6, Rue Condorcet, Paris.
Visseaux, J., Fabricant de Becs et de Manchons ferro-cérium "Visseaux"—87-88, Quai Pierre Scize, Lyon.
Winkler, A., Ingénieur-Civil, Administrateur-Délégué de la Société Wilton pour l'Exploitation des Procédés Chimiques et Foyers Wilton Brebetés—233, Boulevard Antoine Gautier, Bordeaux.
Yeatman, L., Administrateur-Délégué de la Société des Produits Céramiques et Réfractaires de Boulogne-sur-Mer —4, Rue Blanche, Paris.

The PRESIDENT: On behalf of the members of this Institution, I wish to welcome to our meeting the members of the Société Technique de l'Industrie du Gaz en France, who have honoured us by accepting our invitation to join us this year at our annual gathering. [Applause.] It was in October, 1919, that several of our members were able to take advantage of the opportunity afforded by our French colleagues of visiting some of the battlefields of France; and though I was unable to form one of the party on that occasion, I learned from many of those who were there how cordial was the welcome they received, and what great trouble French gas engineers took to make the visit interesting. The most pleasing reports were brought back to this country of the hospitality with which our members had been received. It was with very great regret that we found it necessary to postpone the return visit last summer; and especially was this regretted by Mr. Goulden, who at that time was President, and who had taken a prominent part in the visit to France. That visit made a great impression on all who participated in it—bringing to their notice in the most intimate way how much France had suffered, and with what difficulties French gas engineers had been faced. It made us all recognize more than we had ever done before how great had been the trials, and how still greater had been the determination of our Allies not to be overcome, but to withstand at all costs the efforts of the Germans to bring about their downfall. Gentlemen, Britain had the honour of supporting France. [Applause.] We stood shoulder to shoulder with her in her trials; the blood of our countrymen mingled with that of the sons of France and our Allies in the heroic stand that was made; and we thank God that we are able to share with them the tremendous satisfaction of having prevented the world from being dominated by a race whose domination would have meant the extinction of all freedom. We trust that the effects of the four years' struggle are now being less felt, and that your country may soon be restored to its pre-war prosperity and happiness. With some, losses and privations must still be uppermost in the mind; with others, bitterness and anger will still predominate. But with the mass of your people we trust these feelings are passing away, and that they are settling down to the work of reconstructing their country, of improving the conditions of their countrymen, and of assisting in bringing about better conditions of life throughout the world. In the Arts of Peace, your countrymen have not been less brilliant than in the Arts of War; and we have greatly admired the wonderful achievements and discoveries which have been the results of their labours in the realm of Science. [Applause.]

We are very pleased that so many members of the French Society have been able to visit us. We regret that the visit is to be so short; but we trust it will prove sufficiently long to enable us to get to know something more of each other, and that it will result in knitting still closer the bonds which already unite us. I suppose it is in France as it is here—that gas engineers throughout the whole country have the interests of each other at heart; and I trust that this visit will be helpful in extending those feelings till they embrace the interests of all gas engineers of the two nations. I was struck, when looking through the "Transactions" of your Society—and this has been emphasized by the reports of your recent meeting—to see to what a great extent the work of the two bodies was on the same lines; and undoubtedly a study of the methods and ideas of the other would be of great value to the members of each Association. We trust, M. le Président, that you and your colleagues will find much of interest to you during your visit to the works of the South Metropolitan Gas Company and those of the Fuel Research Board this afternoon, and during your visit to-morrow to the Beckton works of the Gas Light

and Coke Company. Though these works are to some extent representative of the methods in operation in this country, they by no means cover all the systems of gas manufacture, or all the types of plant for the handling of coal or coke which have been adopted in connection with our industry. If more time had been available, much more might have been shown to you; but we trust that there may be sufficient to indicate to you some of our ideas, and we shall be indeed glad if anything which you may see should prove helpful to you in your own works.

M. le Président, I have to hand to you this album, which contains the names of your own members who are visiting us to-day as well as the names of the Council of the Institution of Gas Engineers and of the Past Presidents, who have been invited to meet you. We trust that it will be a memento, and that in years to come it will remind you of two very happy days which you have spent in this country.

M. ELLISSEN, jun., called upon by the President, translated into French the words of welcome, as he did subsequently his father's reply.

M. ELLISSEN: I fully realize how much I am honoured to speak in the name of the Société Technique de l'Industrie du Gaz en France before such an eminent assembly composed of the highest representatives in the gas industry of your great country. I cannot help yielding to the temptation of using my scanty English vocabulary to thank you for your warm welcome. I am also very thankful for the moving remembrance you have just called up. For a long time we have observed the pleasant tradition of crossing the channel, at intervals that we should like to be shorter, with a view to exchanging the expression of our sister corporations' mutual sympathy. We cannot overlook that the tradition began 34 years ago, when, in 1888, my father had the honour of presiding over his French colleague's first sojourn with you. He did not forget then to remind you that the French Technical Association—a younger sister of your Institution—which was made after your own likeness, found all encouragement and example with her elder sister's admirable progressive life. We entertain for the Institution of Gas Engineers respect mingled with affection, such as are due to a near relative occasionally met with, but with so much more pleasure that each fresh intercourse calls forth new common notions and mutual sympathy. Now, gentlemen, I am led to assert with great satisfaction the true, hearty sympathy felt by our 900 members for your Institution and all the members of it. Scattered as they are in the whole French territory—in the largest as in the smallest towns—owing to their interest in your labours and traditional kind welcome, all the French gas engineers constitute as many centres of old strong sympathy with all of you and your great nation.

I, with fifty of our representatives who accompany me to-day, convey the unanimous expression of our sympathy. I know you will be pleased to accept it with your usual kindness, as you are aware of the sincerity and heartiness of our feelings, shown by very old, steady friends, who are always ready to applaud all that can improve and make British industry more prosperous and nobler, and, in the first place, the gas industry, of which I respectfully salute the very honoured representatives in your persons. [Applause.]

The PRESIDENT: I am sure we have listened to M. Ellissen with the very greatest interest; and his words voiced in our own language have been very gratifying to us. I regret that I could not address our French friends in their own language. The French visitors are now about to leave to see the Cenotaph and Westminster Abbey; and Mr. Goulden and Mr. Broadberry will accompany them on behalf of the Institution. We shall hope to meet them again later on.

A Recording and Integrating Gas Calorimeter.

The PRESIDENT: I will now call upon Prof. Boys to give us his paper—see p. 882.

Prof. C. V. BOYS, F.R.S.: It is hardly necessary for me to say what a pleasure it is to come and give the result of two years' work to an Institution of which I know every member, and every one present, is taking a little interest in what I have to say, and how much more satisfactory that is than describing a thing to a scientific society with wider interests and a small fraction only of the members of which would care in the least degree about what I was talking of. The conditions for the reading of this paper are unusually favourable, because I believe, owing to the circulation of the prints, those of you who are interested in the subject have already read it, and for two days those who have been here have had an opportunity of seeing the instrument, which I have explained I cannot tell you how many times. The result is I am not sure whether I have not finished before I have begun; and that being the case, I will, with your President's permission, not read word for word what has been printed, but will discuss the general problem shortly, and dwell at greater length upon some parts of the interior mechanism which, owing to the fact that I cannot make brass and wood transparent, you have not been able to see. Coming to the beginning of all these things, it is the Gas Regulation Act. This requires something of a very superior order, if it is to work smoothly, and with general confidence; and I felt from the very commencement that any casual way of making any of the instruments connected with this difficult problem would not do. The apparatus can all be seen on the table before me.

The Professor then proceeded to give a summary of his paper, aided by a series of lantern slides.

New Honorary Members.

The PRESIDENT: We have only a few minutes left in which to complete the business. The first matter that comes before us now is the election of the respective Presidents of the Société Technique de l'Industrie du Gaz en France, the American Gas Association, and the Italian Association of Gas and Water Engineers as honorary members of the Institution. It has been the custom in previous years to do this; and I have much pleasure in moving that we elect them on this occasion.

Mr. SAMUEL GLOVER seconded this, and it was agreed to.

Place of Next Meeting.

The PRESIDENT: The next item on the agenda is the place of meeting next year. We have with us now the Lord Mayor of Belfast; and I believe he is anxious to say something on this matter.

Sir WILLIAM COATES (Lord Mayor of Belfast): This much I do wish to say, that I am delighted and highly gratified that my good friend Mr. Smith has been chosen to be your President for next year. Very naturally that raises in the minds of those who are responsible for the good of Belfast that it would be a most admirable thing if the meeting of the Institution could be held in that city next year. For this purpose, the President has kindly allowed me to say a few words, and to extend to you a most hearty invitation to come to Belfast for your annual meeting next year. You will receive there a very, very hearty welcome. I shall not then myself, I suppose, be in the position of Lord Mayor, but I will do all I can, as I know my successor in office will do all he can, to make your visit both pleasurable and profitable in every shape and form. I hope you will come.

The PRESIDENT: I am sure we all appreciate highly the very kind invitation Sir William Coates has extended to us to visit Belfast. It is exceedingly good of him to have come across to support Mr. Smith; and we welcome him cordially to our meeting. With regard to the suggestion that we should go to Belfast next year, I think I can say that we should all like very much to do so; but I feel that twelve months hence is a long time to look forward. If when the time arrives our President, Mr. Smith, is still anxious for us to go, I am sure he will receive the support of the members, and have a very good meeting there; and I would suggest we accept the Lord Mayor's invitation, on the understanding that it be renewed nearer the time of our meeting.

This was agreed to.

The Institution of Electrical Engineers.

Mr. SAMUEL TAGG (Preston): I rise to propose a vote of thanks to the Institution of Electrical Engineers for their kindness in granting us the use of their premises for the

purposes of this meeting. They have been admirably adapted to our needs; and so long as the gas industry is in the position of the cuckoo, I hope it will be so fortunate as to have such a comfortable nest.

Mr. JAMES PATERSON (Cheltenham): I am pleased to second that.

The PRESIDENT: I am sure it is not necessary to put that to the meeting. We have had a very enjoyable gathering in this building, which has proved very suitable for the purpose. ["Hear, hear."]

The President's Services.

Mr. GEORGE CLARRY (Cardiff): I have been asked to propose a resolution which I hope you will not take in a formal spirit, but rather in a personal way, because during the last few days it has been our pleasure and privilege to be here under the guidance of our President, who has conducted these proceedings in the most harmonious and able manner. It is not necessary for me to detain you long; for I feel you would be in entire sympathy with anything I might say about his great merits and about that admirable address you heard on the opening day. You have had long sittings; and, speaking as a somewhat old member, it is a long time since I saw such a hearty spirit permeating our meetings. The attendances have been large, and the debates spirited. I think all this has been largely due to the skill and ability of, and the example set by, our President, and the very patient way in which he has governed our proceedings. The meeting this week has been specially important, because there has been an opportunity of returning that hospitality which our friends in France extended to us in the year 1919. It is, I am sure, a matter for congratulation that our President should have had this honour in his year of office. As one of those who went to France, I can bear personal testimony to the fact that our confrères did everything that was humanly possible to make our visit a success; and it is most gratifying that the Chief Engineer of the Gas Light and Coke Company should have the duty of welcoming them now, because Mr. Goulden was acting as President on that occasion, and aroused the warmest feelings of good fellowship in the hearts of the French gas engineers. Again, although we have reached the end of our formal proceedings, we are not yet at the end of our meeting. This evening our President will welcome us to his reception; and in this, of course, we remember that Mrs. Hardie will be associated with him. To-morrow you will be the guests of the Gas Light and Coke Company at the works over which our President rules. I propose a very hearty vote of thanks and appreciation to Mr. Hardie.

Mr. W. N. WESTLAKE (Exeter): I rise to second the resolution so ably proposed by Mr. Clarry, and to say how cordially I agree with all the remarks that he has made. Our President has led us through a splendid meeting. We have had an ample series of thoroughly interesting papers; and Mr. Hardie has fully maintained the traditions of the office of President of this Institution in conducting the proceedings. Our hearty thanks are due to him. We expected he would do well; and we have not been disappointed.

The vote was carried with applause.

The PRESIDENT: Mr. Clarry and Mr. Westlake and gentlemen, I thank you all very much for the cordial manner in which you have received this proposition. The next item on the agenda is another vote of thanks; and I will call upon Mr. Morland.

A Comprehensive Vote of Thanks.

Mr. W. S. MORLAND (Gloucester): It is my pleasure to propose a very comprehensive vote of thanks—to the Council, the Hon. Secretary, the Secretary, the Research Committees, the authors of papers, the Scrutineers, and the Auditors. That will save time. I have been a member of the Institution for very many years; and I must say that I do not think we have had a more successful meeting than on this occasion. We are very much indebted to all who are mentioned in my list. An immense amount of work has to be got through by them. Personally, I have never seen meetings of the Institution so well attended as they have been on this occasion. This points to the fact that those who have had to prepare the papers and reports, and have had to speak, have had something really interesting to say. The whole meeting, in fact, is a proof of the great vitality of this Institution. I am sure that if all directors and members of gas committees knew the benefits their various undertakings obtain from such gatherings, they would many of them be astonished.

Mr. C. H. CARDER (Oldbury): It is my brief and very pleasant duty to second that. The great attention, skill, and assiduity displayed both by members of the Council and authors of papers and reports must meet with our most hearty approval.

The vote having been carried unanimously,

The PRESIDENT said: I think the Hon. Secretary ought to reply.

Mr. W. E. PRICE: With reference to the members of the Council, you know their work; and I am sure what they do is a labour of love. They are very much interested in their work; and when meetings are called they are always fully attended. As to the Secretary, you know Mr. Dunn; and I would like again, as I have done before, to say how much he is appreciated by the Council, by the members, and by myself. I see the work he has to do, and how he does it; and I very much admire the way in which he tackles his job. The vote of thanks is nothing more than his due. That the authors of the papers and reports also deserve the vote of thanks is evidenced by the very large attendances during the week, which shows appreciation of their efforts. The other gentlemen mentioned have also done their work well.

The PRESIDENT: That concludes the business; and I would just like to thank you all for your attendance.

THE PRESIDENTIAL ADDRESS

OF

Mr. THOMAS HARDIE, M.Inst.C.E.,

Chief Engineer of the Gas Light and Coke Company.

Twelve months ago the annual meeting of the Institution was postponed on account of the conditions arising from the serious dispute which then existed in the coal industry. Owing to its high price, the demands of industrial and foreign consumers for coal had become very meagre; and it was evident that if orders sufficient to keep the collieries reasonably employed were to be obtained, a drastic cut in price must take place. To reduce the cost of production, a large reduction in wages was proposed by the colliery owners. The miners were loath to accept so serious a drop in their earnings, and for three months no coal was mined, and very many industries were brought to a standstill.

The Aftermath of the Coal Strike.

After so long a period of idleness as three months, during which stocks of coal had been almost completely depleted, a brisk demand might have been expected; but the requirements of coal users were easily met, and to obtain trade, prices were steadily reduced throughout the remainder of the year. Since the beginning of this year the price of coal has been more in accordance with the economic requirements of the world; and the demand has steadily increased, and is still increasing. The dispute marked the end of Government control and of the artificial conditions which had obtained during the war; and though it was a terrible price to pay for the recovery of free trade, the results have proved of incalculable benefit to the industries of the country. It is to be hoped that the impossibility of regulating by legislature economic conditions has now been fully recognized, and that increased and cheaper production is acknowledged to be the only road by which employment can be found for our population.

In comparing the present with the pre-war price of coal, it must be borne in mind that the former has to carry the deadweight cost of the shorter shift, as the effects postulated before the Sankey Commission—that the output per man would be no less when seven hours were worked than with eight—have proved so far wrong that it is only in the last few weeks that the output per man has even equalled the same output per hour as in 1913. It would seem that British mines are generally not suitable for the adoption of coal-cutting machinery, though the increased labour cost per ton of coal produced may be expected to prove an incentive to the manufacturers of such machinery to renew their efforts to design a plant that will prove suitable and economical for use under the difficult conditions existing in this country.

Capital and Labour.

We have heard a great deal regarding an improved standard of living. The actual standard of living can only be improved by the cheapening of commodities, and this is dependent on the use of more capital, providing more machinery and more efficient plant, which properly used will result in increased output and reduced cost. It can never be attained by simply raising rates of wages or shortening the daily period of labour, and least of all by any policy of "ca canny." Capital will only be attracted to, and permit the extension and development of, those industries that are economically sound. In such industries only is there reason to hope that the way will be made clear for the attainment of the maximum output per man and his higher standard of living.

So the confidence of the capitalist in the workman and the confidence of the workman in the capitalist, and the working of the two together for the benefit of the industry in which they are engaged, will result in their mutual advantage and that of the consumer. Confidence between the capitalist and the worker will be fostered by a greater knowledge by the worker of the business in which his employer is engaged; and everything assisting in this should have support. Among the many advantages of co-partnership, by no means the least is that it stimulates the employee's interest in the financial side of the concern, and in this way leads to better acquaintance with the difficulties of the management, which should teach him to what a great extent he is dependent for his employment on the skill and acumen of that department, as well as how much he and the shareholders have in common. Co-partners in sliding-scale gas companies can scarcely fail, as shareholders and consumers, to understand the great importance of cheapened production, and how much reduced prices influence sales, and thus employment. This also applies to the employees of those companies who have adopted a basic price with minimum dividend, including benefits to co-partners.

One section of the community depends on others; and while the gas industry is affected by the variation in the cost of the production of coal, both the mining industry and the gas industry are largely dependent on the cost of transport. Reduction in the working costs of these two should be supported by similar economies in transport services; if not, they are unfairly handicapped. Though some reductions in dock charges and railway rates have taken place, these are not nearly sufficient. The figures to which these charges should be reduced involve more change than is likely to be obtained by a lowering of wages. Wages paid to railwaymen pre-war may have been low in comparison with those paid to other workers. If so, we can scarcely expect the same proportionate reduction; but that must not prevent the further lowering of railway rates. More efficient working, brought about by improved organization, the use of heavier trains, increased weight drawn per locomotive, and greater service per individual employed, should result in reduced charges; and, if so, the information that such alterations are being made will be welcomed by every industry, especially by those, like the gas industry, which handle large weights of material. The fact that wages represent the greatest proportion of the expenses of the working of a railway, while making us recognize the difficulties of railway managers, does not prevent us from being hopeful that they will be successful in finding means to reduce costs.

Most British industries, in common with the gas industry, depend for their success on cheap coal; and economies effected not only by those engaged in its production, but also those engaged in its transport, are of the greatest importance in enabling all manufacturing industries to produce cheaper commodities. Such economies are essential for the production once more of a period of prosperity, which will allow of the absorption into useful work of the present large unemployed section of the population.

Coal Quality.

Quality of coal is no less important than price; and it is disappointing to find that the improvement in this respect during the last few months has not been more marked. Ash content in qualities known as best gas coals is sometimes in the neighbourhood of 14 p.ct. Before the war there was already a decided tendency towards a larger quantity of inert material in the coal. The average of some hundreds of tests of coals delivered to one undertaking in 1911 was 7·44 p.ct. of ash; while in 1914 the average had increased to 9·51 p.ct. Something less than the immediate pre-war percentage is therefore required. In spite of the adoption of more efficient gas manufacturing plant and closer supervision, it is found difficult to obtain with some coals results which were established in pre-war years. This is undoubtedly due to the poorer quality of the coal. It may be that the coal available to-day is more difficult to clean; but unless colleries can supply coal with less inert material, gas undertakings themselves will have to add to their already numerous processes one for the cleaning of coals. The variation in the percentage of inert material in coal from the same colliery indicates that there is the plant necessary for the work, but that the employees do not carry out their duties under all conditions with the same assiduity.

The proximate analysis of coals is an important guide to their value, provided that the samples are taken in such manner as makes certain that they are fairly representative of the bulk; but such analyses should only be used in conjunction with carbonizing tests when it is desired to determine the relative value of coals from different collieries. Proximate analysis figures by themselves are sometimes very misleading. They may show a coal to contain a large

amount of volatile matter, while a comparatively low yield of therms is obtained, due to the presence in the coal of a larger amount of combined oxygen. On distillation this oxygen combines with some of the hydrogen and carbon to form valueless water and carbonic acid. During the strike period, gas from some of the foreign coals carbonized in horizontal retorts was found to contain 6½ p.ct. of carbon dioxide.

There is yet a very large amount of work to be done in connection with coals before it will be possible to place on different brands their relative monetary value for gas making, and these values will always vary considerably for each type of carbonizing plant in which they are to be used. The experiments carried out at the Fuel Research Station have added considerably to our knowledge of the characteristics of coals. Mr. Linton, of Leith, in his tests of coal some thirty years ago drew attention to the variation in the rate at which different coals gave off their gas; and in the interesting work Dr. Weyman has done on the rate of gasification of coal he has shown how distinct in this respect are the qualities of coals from the same coal-field. A coal that gives off its total volatile matter at a low temperature will require the expenditure of less fuel, having besides the advantage of the easier production of the maximum quantity of gas.

The conductivity of coals or their permeability to heat is another property on which information is required. Some of the surprisingly different results obtained from similar coals under the same conditions of carbonization may be explained by more investigation of their properties under test conditions; while the information would prove valuable in determining the possibility of the successful handling of a coal in the new carbonizing systems.

The passing of the Gas Regulation Act is proving a great incentive to inventors. The freedom of choice of a standard of calorific quality, it seems to be generally thought, must eventually evolve the production of a gas of new composition under novel conditions. Proposals for the gasification of coal are bewildering not less by their variety than by their number.

The Charter of Freedom.

The 1920 Act has been very rightly described as a Charter of Freedom; but in this case, as in most others, freedom means increased responsibility. In former days the quality of gas was discussed and scrutinized by representatives of local authorities, by King's Counsel, and by Parliamentary Committees; and there was little chance for eccentricity or individuality, much less mistake in declaration, to pass without modification. To-day the quality of gas to be declared as the standard has to be decided by an officer of the undertaking; and there is no check outside that undertaking on his proposal. The responsibility has been felt; and it is not surprising that we find great caution being exhibited, and standards showing little variation from qualities which experience has proved safe in working being generally declared. Caution has been carried still further by an ample allowance in many cases being made to ensure apparently that the undertaking will not, even under the worst conditions, come within the penalty line. Consumers under such conditions are receiving more than their value; but working experience with recording calorimeters will soon show that so much generosity is unnecessary, and the therms supplied will shortly approach more nearly to those which are paid for. The declarations of standard quality that have been made indicate very strongly that undertakings appreciate that the first thing to be attained is the giving of satisfaction to the consumer.

Thinking in Therms.

The sale of gas by therms instead of cubic feet has made engineers consider the production of gas from a different basis. It has been said "learn to think in therms;" and every effort is being made to do so. Makes of gas have been stated in therms per ton of coal carbonized; wages have been calculated to pence per therm; capital has been converted to pounds per therm; but I do not think we find the figures convey their meaning quite so clearly to the mind as do those based on 1000 c.ft. of gas or per ton of coal, while there is almost always at least a little hesitation before we are able to give the therm consumption of a burner used either in lighting or heating. In practice, the method of charge by therm involves the multiplication of two measurements—one of quality and one of quantity, each of which separately conveys something definite to our minds; and their distinctness of character can scarcely be lost sight of in thinking of the value of the gas. In spite of this complexity, I am satisfied that the system of charging by thermal value is that by which the consumer can best obtain satisfaction.

Advantages of Water-Gas Plant.

The adoption of the therm as the unit of charge will have more influence in determining the quality of gas to be supplied than the freedom the Act gives in the fixing of the actual standard. The standard must be declared at a figure which will permit of the most economical production of therms with the available gas-producing plant. With horizontal and inclined retorts, highest efficiency accompanies the production of gas of fairly high calorific value. Steaming of vertical retorts and the use of blue water gas plants depend for their economical working on the market value of coke; while lower prices for gas oil may easily make highly carburetted water gas the carrier of the cheapest therms. The control over the production of residuals which water-gas plants facilitate is a factor which it is impossible to value too highly; while the ease with which any variation in the quality of the coal gas can be balanced by an increase or decrease in the use of oil will prove of great advantage in maintaining without loss a steady calorific value. The change in the method of charging for gas has therefore added further to the advantages of these plants, which have always been considerable

Total Gasification.

New systems of carbonization involving total gasification cannot be regarded favourably until wages and markets have reached more stability. They must show large economies if they are to replace existing plant, as they will have to bear the charges of the obsolete capital they replace; but for meeting new consumption demands they should be carefully considered. The permissible variation of the standard allows modifications to be made in the quality of the gas to be delivered suitable to the possibilities of any new system; but increased cost per therm in the distribution of lower qualities of gas must be charged against systems producing such lower qualities.

The change in the unit of charge to the consumer, and the freedom in fixing a standard, has interested in gas manufacture many others than those directly engaged in the production of a gaseous fuel for domestic and industrial purposes; and it is all to the good that it is so, as those outside the industry in most cases view the subject from an entirely fresh standpoint.

Low-Temperature Carbonization.

Low-temperature carbonization is not a very new suggestion; but it is a process which its advocates have urged with great confidence, and in some cases with no little aspersion on the perception and capacity of the gas manufacturer. Its advantages and disadvantages have been so frequently stated that no good purpose can be gained by repeating them. More moderate views are now being expressed by some of its adherents, who recognize the possibility of financial success to the system by its adoption as an adjunct to gas-works, where it is suggested the high-quality gas might be used for increasing calorific value. Although this proposal has merits, unless the demand for the solid and liquid residuals is sufficient to produce favourable prices for them, it is probable that, even to this limited extent, the value of the low-temperature system as a carbonizing process will prove a financial failure.

Coke-Oven Gas for Town Supplies.

Another proposal which has been before us for some time is that of the purchase of the waste gas of coke-ovens. This has now been adopted in several cases; and where agreements have been entered into on the basis that the surplus gas which is available from coke-oven plants is waste, there has been evident advantage to the gas consumer, the gas undertaking, and the coke-oven owner. Actually there is very little waste gas, properly so-called. Coke-oven managers have in most cases long since found the value of any surplus gas; and there are few places to-day in which all the gas has not a very definite value. It is generally used for raising steam by burning under boilers, or in the production of power by employment in

internal combustion engines, to meet the requirements of the coke-oven plant or the adjoining colliery, while it is also sold to public electrical undertakings for the production of power.

Where a gas undertaking purchases coke-oven gas for the purpose of meeting new consumption for which they themselves have no producing plant, there is little difficulty in determining the value of the supply, providing the undertaking is prepared to accept the risk involved in the maintenance of their supply of gas to their consumers, though even in this case allowance must be made for the proportion of plant which is put out of action during the summer period. When a supply is taken, which displaces producing plant all the year round, many items must come under review in calculating the economic price.

A supply of coke-oven gas is usually of uniform quantity throughout the year; and therefore, if it represents any substantial proportion of the total output, the larger reduction in the summer make of the gas-works plant may seriously affect its efficient working during a long period. The discontinuance of the operation of a gas-works plant must carry with it a charge against the new supply for the interest on the capital so prevented from earning profit, as well as a charge for the proper maintenance of such plant. Most undertakings would consider it advisable to make arrangements which would make certain that no interruption, due to a strike at the coke-ovens or a failure from any other cause to supply continuously, should occur in the fulfilment of the undertaking's obligations to the public. The experiences at Middlesborough prove such arrangements to be advisable, and in the case of statutory undertakings it is obvious that the provision of an alternative supply must be regarded as essential. The reduction of the output of a works due to the purchase of a supply of gas affects the maintenance charge of the carbonizing plant and also the subsidiary plant; and the new supply must bear its proportion of the cost of the maintenance of any plant the use of which has thereby been curtailed. Otherwise the works charges upon actual output will be greatly increased, and will unduly handicap the gas production of the works, compared with the purchased supply. This figure may easily reach several pence per 1000 c.ft. Unless the amount debited for maintenance in the contract price of the gas is used by the undertaking for the upkeep of its plant, it would find itself seriously penalized when the time came to enter into a new contract, through the accumulation of arrears of expenditure which would be required to put its own plant again into operation. The efficient maintenance of its plant might at the end of the period still leave the undertaking adversely affected if, during the contract, the particular plant had become obsolete. It is necessary, therefore, that the price of gas obtained from coke-ovens or any other source should be sufficiently low to allow of proper sums being set aside each year, so that the undertaking may not be left at any time with plant less efficient than it would have possessed had its plant been continuously in operation, unless the full capital value of the plant has been written-off.

Experiences of Total Gasification.

Plants capable of total gasification of coal are now in operation at several works. The system generally adopted consists of a vertical retort superimposed on a generator into which the coke falls by gravity, though systems in which coke is discharged from horizontal retorts into a generator are also successfully operating. In addition, vertical retorts are frequently steamed to such an extent that total gasification is approached, and during the strike total gasification results were produced by the combined use of coal-gas and water-gas plants. The object of the advocates of such systems is the production of increased therms per ton of coal, and lower cost per therm. The great variation in the values of coals, bye-products, and wages has made it difficult to formulate a definite estimate of the value of the newer systems, besides which the information regarding the working results and costs has not been available in very complete form. Their advantages may be greater when used in conjunction with plants producing high-quality gas than for production of gas for distribution unmixed. It is doubtful if efficiencies in total gasification plants, in which external heating is used, will balance the disadvantages, especially for general distribution purposes, of unduly low-quality gas. It has been advanced by a few who have had experience in distribution of low-quality gas, that the increased costs are more imaginary than real.

There has been very many years' experience of the production and distribution of a low-quality gas in the Midlands, where Mond gas has been supplied for industrial purposes. Although the thermal value of the gas is much lower than has been suggested for general domestic use, a study of the known facts in connection with this supply would provide some valuable information on the practical advantages and difficulties which may result from the adoption of a very low standard, and also a guide to the financial aspect of the proposal.

Schemes are now proposed in which either total or partial gasification can be effected by means of internal heating, without loading the gas produced with excessive quantities of inerts. Low conductivity, so prejudicial to the carbonization of coal in bulk by external heating, almost disappears with internal heating; but with caking coals means must be adopted to prevent any stoppage of the freeway for the heating gases and products.

In one system a rotary retort is used, water gas is preheated and passed through the coal at an initial temperature of 800° C. Low-temperature coke, which may be sold for domestic purposes or used in the water-gas generator, is produced; and with total gasification it is estimated to produce 36,000 c.ft. of gas of a calorific value of 400 B.Th.U.

Employment of Oxygen.

Another proposal for total gasification is that in which oxygen is to be used in the manner which was brought to our notice by Prof. Cobb and Mr. H. J. Hodsman in the very interesting paper they read at our Annual Meeting two years ago. A plant for the manufacture of oxygen has been designed in America on the Jefferies-Norton system, by which the cost of production decreases rapidly as the output of the plant increases, until, with an output of 3,000,000 c.ft. per day, it is estimated that the oxygen would be produced at 5d. per 1000 c.ft. The plant for the production of oxygen at this rate would cost about £100,000. Three million cubic feet of oxygen would gasify 217 tons of coal and produce about 15,000,000 c.ft. of gas. Mr. Jefferies states that the gas from American coal would have a calorific value of 400 B.Th.U.; but Prof. Cobb estimates with English coal the quality would be 352 B.Th.U., and on the latter figure 243 therms would be obtained from one ton of coal.

With the price of oxygen at 5d. per 1000 c.ft. the cost of gas produced from one ton of coal might work out approximately as follows:

	s.	d.
Coal into producers	35	0
Steam, 672 lbs.	1	0
Oxygen, 14,000 c.ft. at 5d.	5	10
Labour	2	3
Wear and Tear and Interest	2	4
Total	46	5

On the assumption of 243 therms per ton, this estimated cost of production would give a cost per therm of 2·3d. In my opinion, the advantages should be more definite and greater before an undertaking would be justified in embarking on such a scheme at an expenditure of £100,000.

In view of the possibility of further reduction in the cost of oxygen it would be well if some experiments could be made to ascertain what will actually occur in a producer if oxygen diluted with steam only were used. It might be that experiment would indicate that the conditions in the producer were somewhat different from those expected, and that the estimated results required considerable modification. From the fact that gas produced by such a system would contain over 50 p.ct. of carbon monoxide, it is most unlikely that such a gas by itself would be considered suitable for domestic purposes.

Coal Briquetting.

Messrs. Sutcliffe and Evans, in a paper before the Chemical Society in April, described their method of briquetting coal, in which no binding material is used. The briquettes consist of a mixture of finely-ground breeze and coal, and on carbonization the briquettes retain their shape. It is thought that the formation of these briquettes will permit of their being carbonized in bulk by internal heating; and a plant has been designed in which the coal would be carbonized by the passage through it of the

produced gas, which has been heated in a recuperator. The temperature of the recuperator is to be maintained by the combustion of a proportion of the gas. This, again, is a process of great possibilities, in which gas and coke in varying proportions and of good quality might be produced.

Besides those mentioned, there are many other very novel and ingenious proposals for the manufacture of gas, and there are also in progress developments on the lines of the ordinary recognized methods. Both in horizontal and vertical systems of carbonization improvements are regularly being made in construction; while better supervision and more scientific control are having good effect on the results obtained from these improvements.

The Question of Refractory Materials.

Attention has been drawn in the reports of the Gas Investigation Committee and elsewhere to the thermal losses in retort-benches due to radiation and the sensible heat of the waste gases; and steps have been taken in many settings to increase economical working by the use of non-conducting materials in the one case, and by the use of waste-heat boilers and more efficient control in the other. The advantages of a dry main, adopted so generally in vertical retort settings, are now being sought anew by those working horizontal settings; while the necessity for working to higher temperatures has suggested improvements in furnaces, which have also been beneficial in fuel consumption. Combustion chamber temperatures up to 1350° and even 1400°C. are now found advantageous in the production of a large number of therms per unit weight of coal carbonized, and the need for refractory material capable of standing the higher temperatures is making the use of retorts containing large percentages of silica material almost essential. Makers of retorts and of all classes of refractory material have met the demand for higher quality in a very satisfactory manner, though, of course, there is still room for improvement. It may be that it is the influence of the Refractory Materials Research Committee; but the general standard has certainly advanced, and makers appear to have recognized the necessity for supplying goods which will not only withstand the more severe conditions, but will do so with less variation in the way of expansion or contraction.

The result of the altered working of horizontal retorts demonstrates that under ordinary working conditions, with coal of reasonably good quality, makes of 13,250 c.ft. per ton, of 540 B.Th.U. quality, are obtained. In making comparison, therefore, with results taken under test conditions of new systems the figure for working with horizontal retorts should certainly not be less than 71 therms, and may have to be taken at 74 therms per ton.

Chemical Control.

The advantage to be derived from regular analyses of the composition of the gas being made for sale, of producer and waste gases, and of all things affecting the gas or bye-products is increasingly recognized. Gas manufacture is largely a chemical process; and the development of the mechanical part of the plant has made proper chemical control more than ever necessary. Chemists have taken in recent years a much more prominent part in the work of the production of gas. Every works of substantial size has customarily a chemical staff, including men of special qualifications and high scientific attainment; and their help in the improvement of the results is gratefully recognized by engineers.

It is not sufficient that tests and analyses should be made; these must be studied, the reasons for variations sought for, and action taken by the engineer to create conditions which the tests indicate give the best results. Records of all analyses should be kept, averaged over periods, and compared, remembering the conditions existing at the time they were made. The tests should be put in a form in which they are easily understood, and convey to the engineer at a glance any faults which are occurring in his plant. It is desirable to fix standards, departure from which calls for immediate attention. Chemists should be required to give explanations of the variations in their figures—in many instances their more thorough knowledge of chemical reaction has explained in simple manner what previously were very puzzling enigmas. It is only by taking full advantage of the chemist's knowledge thus available that proper value is obtained by the addition to the staff of these highly qualified observers.

It is the chemist who has brought to our notice the possibilities of improved chemical efficiency, and pointed out very many of the small unnoticed faults through which losses occur. Chemists often have Utopian views and see visions. Visionaries are very necessary for progress, and the term is used in no derogatory sense, as it is only by the study of pure chemistry in connection with our industry that the information necessary to determine the best lines on which gas should be manufactured can be obtained. The commercial side of the matter must, however, receive consideration from others than pure scientists before the schemes of chemists can be adopted without risk of financial loss. In an article in "Engineering" dealing with the influence of physics in engineering problems, the following sentence occurred: "Pure science was an invaluable servant to the engineer if it assisted him in his setting his house in order and served him in a new activity; but it was a bad master if it induced him to undervalue his inheritance from the accumulated results of the labours of his predecessors." Experience is not less important to the gas manufacturer than to the engineer; and chemistry will prove most useful when used in conjunction with knowledge obtained by long practice. There is no doubt that a first-rate chemist in a gas-works is a sound financial proposition, provided his services are properly used, and the meaning of his work fully understood by those in control of the operation of the plant under consideration.

Reduced charges for gas are imperative to-day. The enhanced value of gas stocks shows not only that the public have confidence in the commercial soundness of our business, but they are expecting to see the lower costs of raw materials and labour translated into increased profits and cheaper gas. Decreases in consumption, despite unemployment, strikes, and lock-outs, have not been excessive. The consumption through automatic coin meters, which forms so large a proportion of our demand, has been maintained better than might have been expected in the circumstances. It indicates how necessary gas is to the general community — that, notwithstanding smaller incomes, the gas requirements are among the last to be affected. It also probably points to the fact that a part of the sums which gas undertakings have paid in rates and taxes, and which may have been distributed in the form of unemployed allowances, has assisted in maintaining a steadier output from our works.

Economies and Higher Efficiencies.

While every undertaking is endeavouring to reduce the price of gas by studying improved and cheaper methods of producing therms in the retort-house, the possibility of effecting economies and higher efficiencies in other parts of the plant is not being overlooked. Considerable attention has recently been given to the production of steam. The fact that coke breeze was formerly somewhat of a drug on the market made gas engineers frequently less careful in its use than present conditions require; while the high cost of gas into the holders makes a close examination of its use within the works, whether it be for lighting, heating, or power, one well worthy of attention. Plants and systems for the recovery of tar and ammonia, as well as for purification, are all being examined with the object of reducing cost, and at the same time steps are being taken to supply gas in a condition which will reduce maintenance costs in mains, services, and meters, and remove annoyance to the consumers and cost to the undertaking by prevention of naphthalene stoppages. In all these several directions we are hopeful of obtaining economies or more efficient working which will result in gas being produced more cheaply.

Of any reduction in the charge for rates and taxes, now generally exceeding ½d. per therm—being outside our control—we are less hopeful; while we feel for many reasons that distribution costs are unlikely to decline as rapidly as we could wish. There should be no reduction in cost that will lessen the efficiency of the service to the consumer—in fact, better service should be given. Price is an important factor always in selling; but for retention of custom there must be satisfaction of the purchaser. Approval of the consumer must be obtained; and for this it is not necessary to be constantly inquiring if he is satisfied, or what more he requires to be done, as unnecessary inquiries give rise to a feeling of annoyance. Gas is practically a necessity in every household, and is essential to comfort. Any defect means discomfort and annoyance. Therefore defects must be prevented. Defects are due to two causes—the supply itself or the fitting.

The supply should not vary more than *plus* or *minus* 5 p.ct. in quality, and must be delivered at a suitable and constant pressure. Provided the piping is ample, and the fittings are of good quality, troubles will be few. Constant quality, regular pressure, ample piping, and well-made appliances, these four conditions satisfied, a reduction in maintenance costs should be obtained simultaneously with greater satisfaction to the consumer.

Efficient Workmen.

A frequent cause of annoyance to the consumer is the ineffectual attention to a fault; and one of the chief causes of lost business to a gas undertaking is the inefficient workman. Therefore, well-educated, well-trained and competent men with the interest of the undertaking at heart, are essential for satisfactory maintenance. Such men can be obtained if their advantage is sufficiently recognized by the management.

More expensive road construction and the erection of fewer houses pe. acre may result in permanently increasing distribution costs; but on the other hand standardization, such as that just completed for gas-cookers, it is hoped will result in considerable reduction both in first cost and in maintenance of consumers' appliances.

The Value of the Lighting Load.

The advantages of gas for heating and cooking are now so generally admitted, and the need for labour-saving appliances in the household has become so urgent, that increased consumption for these purposes has for some years accumulated with little effort, and has proved an important factor in the success of our business. The value of the lighting load must not, however, be forgotten. It was for lighting purposes that gas was in the first instance supplied; and during the hundred years the business has been in existence, many millions of lighting burners of various descriptions have been utilized. The consumption of gas through any of these burners should in no instance be lost without serious effort being made to retain it. It is much less costly to a consumer to replace an out-of-date or faulty gas-fitting by one of newer type, the efficiency and lighting effect of which cannot be surpassed, than by an installation of electric light. Unless the consumer has been allowed to become too dissatisfied through unsuitable quality or inferior maintenance, retention of gas lighting should be possible.

Owing to the simplicity with which gas can be stored, it possesses a great advantage over electricity for meeting the lighting load. The provision of storage by a gasholder permits of the lighting consumption being spread over the whole twenty-four hours' manufacture; and the increased demand for gas for purposes other than lighting has reduced in recent years the proportion of capital required for storage purposes.

The lighting consumption requires less to-day in capital charges than ever before, and can easily be carried without additional price; while electrical undertakings are charging in some cases five or six times as much for current used for lighting as for cooking or heating. Gas has therefore advantages in competition with electricity for lighting purposes; and if burners properly adjusted to suit the quality of gas supplied are installed and well maintained, increases in the lighting load should not be less familiar than increases in consumption for other purposes.

The Outlook.

The history of the gas industry shows that gas has to an ever-increasing extent met the requirements of the public. During its existence, difficulties there have always been; restrictions have frequently been onerous; competition has been severe—it is over fifty years since the advent of electricity; yet there has been rapid and steady development of our business. To-day there are still difficulties. Ignorance in some quarters and prejudice in others have yet to be overcome. Departmental Committees, Electricity Commissioners, and super-stations are all being used to bolster up electricity, so concentrated competition may be expected. Yet we in the gas industry, with knowledge of its capabilities and possibilities, have never been so sanguine of success, and have never felt so confident that our business will continue to flourish. Further development will result in extended conservation of our national resources, in increased efficiencies and economies in the industrial world, in healthier conditions in our towns, and in greater comforts in the homes of the people.

Masonic.

An Emergency Meeting of the Evening Star Lodge was arranged for Monday evening, June 19; and there was a large attendance of visiting brethren from the Institution of Gas Engineers. It took place in the Grand Temple, and was followed by a dinner and concert in the adjoining Connaught Rooms. W.Bro. Frank Jervis, the W.M. of the Lodge, presided, and was supported by all the officers and many members of the Lodge. Tribute was paid to the memory of W.Bro. Walter King, the oldest Past-Master, whose recent death was announced, and very sincere sympathy was expressed.

Arrival of Our French Colleagues.

The members of the Société Technique, with their President (M. R. Ellissen) and the Vice-Presidents and Secretary, arrived in this country in two parties on Wednesday afternoon and evening. On behalf of their hosts—the Institution of Gas Engineers and the Gas Light and Coke Company—they were met by the President of the Institution (Mr. Thomas Hardie), the President-Elect (Mr. J. D. Smith), Mr. Thomas Goulden, Mr. A. E. Broadberry, and Mr. Walter T. Dunn.

The Société Technique at the Cenotaph and Abbey.

After the gracious reception on Thursday morning by the President of the Institution (Mr. Thomas Hardie) of the President, M. R. Ellissen, Vice-Presidents, and members of the Société Technique, the visitors left the meeting place, and, under the guidance of Sir R. S. Gardiner, Mr. Thomas Goulden, and Mr. A. E. Broadberry, visited the Cenotaph. There M. Ellissen, on behalf of his colleagues, paid homage to our dead soldiers by depositing a wreath at the foot of the memorial. Afterwards they visited Westminster Abbey; and there too they paid their respects to our Unknown Warrior representing the great army of men who laid down their lives in the cause of right and freedom. At the Abbey, the visitors were received by Bishop Ryle, and conducted round the historic building.

Visit of French Engineers to Greenwich.

On Thursday afternoon, the President and members of the Société Technique paid a visit to the East Greenwich works of the South Metropolitan Gas Company and the Fuel Research Station.

Reception and Dance.

On Thursday evening, the President of the Institution and Mrs. Hardie held a reception, with a dance, at the Galleries of the Royal Institute of Painters in Water Colours, Piccadilly. The occasion was exceptionally interesting, in view of the visit of the members of the Société Technique. Altogether, the President and Mrs. Hardie had the pleasure of receiving no fewer than some 500 guests—we believe a record number—and they did this with every sign of happiness and satisfaction right away to the coming of the last visitor. The galleries presented a very gay appearance, and at times the ball-room was almost uncomfortably crowded; but everyone, including the French guests, evidenced the greatest pleasure. Notwithstanding the attractions of the ball-room, the refreshment and ante-rooms were throughout the evening also well filled. Wandering round, one came across Sir Dugald Clerk, Mr. D. Milne Watson, Dr. Carpenter, Dr. Hele Shaw (the President of the Institution of Mechanical Engineers), our veteran friend Mr. H. E. Jones (who despite his years still indulges in waltzes and one steps), Mr. A. M. Paddon, Prof. Bone, and several others. Here, there, and everywhere we seemed to see the President and Mrs. Hardie engaged in conversation with different groups of their numerous guests. From beginning to end, the evening was one of great delight to all who were fortunate enough to be present, and quite at the end, when the hour was drawing on to midnight, there were still enthusiasts who would have liked to have the attractive programme extended.

The "New Cooker" of Radiation Ltd.

The Directors of Radiation Ltd. took the opportunity, during Institution week, to invite gas engineers to Radiation House, Grosvenor Place, to inspect the "New Cooker" to which references have already been made in the press from time to time. These cookers embody the result of many years' work and investigation by the individual firms associated with the Company and their combined efforts during the last two or three years. The cookers are constructed on entirely new lines; their efficiencies are a great advance, and due regard has been given to the important question of the cost of maintenance. Great interest was shown by the visitors who inspected these cookers and witnessed the demonstrations. Figures were given to them, and charts shown, which aroused the greatest enthusiasm and appreciation of the excellent developments and advances that had been made in the construction of these stoves. In due course full particulars will be published; and the general public will then realize what an extraordinary development has been made in gas-cookers. Visitors also had an opportunity of examining many important features embodied in the "Standard" fires with "Thermo XX." radiants and injector-ventilator patents

REPORTS OF COMMITTEES, PAPERS, AND DISCUSSIONS.

GAS INVESTIGATION COMMITTEE.

STATEMENT WITH REFERENCE TO THE INVESTIGATION OF AERATION IN ATMOSPHERIC BURNERS.

By Prof. J. W. COBB.

I may say by way of introduction that the Research Sub-Committee have not changed either their members or staff during the past twelve months, and that Prof. Smithells has continued to act as Chairman, displaying the same interest in the doings of the Committee as has marked his Chairmanship throughout. At this time of the year University claims are very exacting, or Prof. Smithells would be here.

We have been engaged on two kinds of work, the first being an investigation into the aeration of atmospheric burners of the bunsen type, and the second the testing of a carburetted water-gas plant with waste-heat boiler.

The first branch of work is what I wish to deal with. Nothing was plainer from the results of the work we carried out on the efficiencies obtainable from different grades of gas in various appliances than the importance of aeration as a factor in determining the result obtained in any case. In that connection I need only refer you to the reports that we have already issued. Moreover, as the grades of gas or conditions of use become more varied, and depart more widely from the normal coal gas, it becomes more difficult, but necessary, to forecast what will be the position as regards aeration resulting from any change that may be made. It is, to give a very simple example, very necessary to know what will be the position as regards aeration if the density of the gas is increased or diminished. You may feel inclined to assume that such a simple thing has already been established with certainty. If, however, you look into the literature of the subject, if you read the evidence given before the Board of Trade's Committee of Inquiry into Inert Constituents of Gas, that impression will disappear, particularly if you have in addition the sort of correspondence on the subject that has come my way. It is plain that the very rudiments of the subject require to be established experimentally. This was what we started to do.

The difficulty of drawing conclusions from day-to-day experience or in making experiments on aeration which will lead straight to definite and quantitative results, arises in the first place from the number of factors involved. The first of these is the injector action pure and simple. The gas issues from the nipple of the burner with a velocity depending on the pressure behind it, sweeps up, as it were, some of the surrounding air, and the mixture of gas and air then passes along the tube of the burner. That is the process of primary aeration effected by injection pure and simple; but the extent of the aeration is influenced by other circumstances. The resistance offered by the walls of the burner tube, or by any constriction or obstacle in the burner tube, or at the outlet, will make a difference. So will the position of the burner tube, as to whether the passage of the gas-air mixture is upwards, downwards, horizontal, or at an angle, because the gas-air mixture in the tube is lighter than the air outside, and a chimney or syphon effect is the result, this being intensified if the burner is lighted. As a simple illustration of that, I might take the case in which you attempt to inject a gas-air mixture downwards through a tube. You can do it with a certain length of tube, as is, of course, commonly done in the inverted burner; but if you gradually increase the length of the tube downwards, you come to a point at which the upward pressure of the air outside the tube overcomes the injecting effect, and gas escapes from the top of the tube and does not go down the tube at all. What I want really to insist upon is the importance of the position of the tube in determining the amount of air, that effect being brought about by the difference in density, and if the gas is lighted the effect is intensified. We therefore turned our attention, in the first instance, to the study of the injector action in its simplest form.

We took a simple glass jet discharging into a glass tube open at the far end and placed horizontally. The tube was made of sufficient length to ensure complete mixing, and the degree of aeration was determined by chemical analysis. We then varied, as required, the pressure, density, and composition of the gas, the length of the tube, its outlet resistance, its inclination to the horizontal, and other factors.

The results that we have obtained so far definitely discourage the idea that much can be calculated from formulæ as to the performance of a burner, except within narrow limits.

There has been a tendency in technical literature to simplify calculation by making assumptions which cannot be justified. The simplest of these is that the gas issues from the nipple with a certain momentum and shares that momentum with the injected air, so that the speed of the gas-air mixture and the quantity of the air injected vary in accordance with the simple assumption that the total momentum remains the same—*i.e.*, that the momentum of the gas-air mixture remains the same as that of the original gas; the original momentum of the air being, of course, *nil*. This is the method most generally followed; but it had no experimental justification.

Another simple assumption which is sometimes made is that the gas shares with the injected air, not its momentum, but its kinetic energy. This leads to quite different results. Sometimes you see the calculation made on one assumption, and sometimes on the other assumption. Either of these assumptions, according to our experiments, is equally untenable, nor have we found that either can be made to hold by the introduction of a constant into the formula. There might be a sort of idea—it is conceivable—that you are dealing with a machine the efficiency of which might be regarded as constant within limits; and, if so, it would be possible to make a formula introducing a constant, the constant being an expression of the efficiency of the injector working as a machine. This seemed a possible kind of thing which could be considered; but, again, the Committee have no reason for assuming that it is the fact.

The American Bureau of Standards has put forward the view that there is a constant ratio (as distinct from equality) between the momentum of the injecting gas jet and that of the air-gas mixture issuing from a burner, so long as the mechanical condition of the latter—*i.e.*, the burner—is unaltered; that this ratio is a characteristic constant for each particular burner, despite variations in gas rate, pressure, or specific gravity; and that it can be experimentally determined.

In our tests this rule has not been found to apply with low velocities of air-gas mixture such as the gas industry in this country has to use. It has been found to hold approximately in some of our burner tests when the velocity of the air-gas mixture was high. The more exact specification of the conditions under which the rule holds is very desirable, but entails further investigation.

Some positive results have been obtained on a matter which is of considerable and immediate importance to the gas industry; they do indeed provide an answer to a question which is always arising, and that is what change, if any, is likely to take place in aeration when the pressure, or particularly the specific gravity, of the gas is altered. We have found that within wide limits, working with the same burner and jet, there is an increase in the aeration (1) When the pressure (and therefore gas rate) is increased using the same gas, or (2) when the specific gravity of the gas is increased, whether the comparison is made at equal gas rates or at equal pressures.

SEVENTH REPORT OF THE RESEARCH SUB-COMMITTEE OF THE GAS INVESTIGATION COMMITTEE OF THE INSTITUTION OF GAS ENGINEERS.

Adopted by the Gas Investigation Committee, May 30, 1922.

RESEARCH SUB-COMMITTEE.

Chairman: Professor Arthur Smithells, C.M.G., B.Sc., F.R.S.

Representatives of the University of Leeds: Professor J. W. Cobb, C.B.E., B.Sc., F.I.C. (Honorary Secretary), Professor J. B. Cohen, Ph.D., F.R.S., and Mr. G. R. Thompson, B.Sc. (One vacancy.)

Representatives of the Institution of Gas Engineers: Messrs. H. E. Bloor, B.Sc., B.Eng., J. Bond, O.B.E., J. H. Brearley, M.Inst.C.E., T. Glover, C.B.E., M.Inst.C.E., C. Wood, O.B.E. Mr. T. F. E. Rhead, M.Sc., was co-opted a member of the Research Sub-Committee for the purpose and period of research work at Birmingham.

Research Chemists: James W. Wood, M.Sc. (Tech.), A.I.C., on the relative efficiencies in use of different grades and compositions of gas; A. Parker, D.Sc. (Birmingham), M.Sc. (Manc.), A.I.C., on the comparative economies in production of different grades of gas.

Research Assistants: H. Kerr, A.I.C., Diploma Fuel and Metallurgy (Leeds), F. S. Townend, B.Sc. Eng. (London), and G. B. Howarth, M.Sc., Gas Engineering (Leeds), A.I.C.

No change has taken place in the constitution of the Gas Investigation Committee during the year, and the Joint Committee on Gas Heating, Lighting, and Ventilation Research, of the Institution of Gas Engineers and the University of Leeds, has continued to act as Research Sub-Committee. The staff engaged upon research work has also remained unchanged.

During the past twelve months research work has been carried out in two parts under the supervision of Prof. Cobb.

The first part of the work consists of an investigation into the injector action as occurring in atmospheric burners. This marks a return to the study of the behaviour in use of different grades of gas, which had to be suspended for twelve months in order to allow of the investigation on Recording Gas Calorimeters, the results of which were embodied in the Fifth Report last year. The work bears upon questions which will become more urgent if the grades of gas are varied more widely, and requires that a large number of experiments should be made on gas mixtures of known density and composition under carefully ascertained conditions. Mr. James W. Wood (Research Chemist) has been engaged upon this problem, assisted by Mr. G. B. Howarth.

The second part of the work has been the study of a carburetted water gas plant with an attached waste-heat boiler. The results obtained will supplement usefully, it is believed, those reported last year for a blue water gas plant. This work has been in the immediate charge of Dr. A. Parker, assisted by Mr. H. Kerr, Mr. F. S. Townend, and Mr. G. B. Howarth. The actual control of the carburetted water gas plant was in the hands of Mr. G. C. Pearson, of the Birmingham Corporation Gas Department.

The Committee would like to acknowledge the skill and zeal which has been displayed by the members of its staff.

The facilities required for both branches of investigation were once more afforded by the Birmingham Corporation Gas Department, and the Committee takes this opportunity of expressing its thanks to the Department, as also to its staff, for the help they have rendered.

SECTION 1.

INTRODUCTION AND GENERAL RESULTS.

This report describes the third part of the investigation into the thermal and chemical efficiencies of manufacture of different grades of gas by various processes. The first part of the investigation which dealt with the process of steaming in continuous vertical retorts was carried out at the works of the Bothwell and Uddingston Gas Company, and is described in the Fourth Report. The results of the Uddingston tests proved that with proper control of the conditions, such as throughput of coal, temperatures of the setting, rate of admission of steam, &c., considerable advantages are to be gained by *moderate* steaming. The report shows that the thermal efficiency of gas production rose from 54·4 p.ct. without steam to a maximum of 62·1 with steam, and at the same time increased yields of tar and ammonia were obtained. The results generally were afterwards confirmed by the work on this subject carried out at the Research Station of the Fuel Research Board, and described in a paper given to the Institution by Sir George Beilby last year. It has since been calculated (*vide* Sixth Report) that if the steam required for the retorts could be raised by waste heat boilers (and it is probable that it could) the efficiency of 62·1 p.ct. would be increased to 68·5 p.ct.

The next step in the investigation described in the Sixth Report was carried out at the Adderley Street Works of the Birmingham Gas Department, with the object of determining the efficiency of production of blue water gas as ordinarily practised in a plant without waste heat boilers. It was found that, taking into account the steam required for the operation of the plant, the efficiency of gas production averaged 46 p.ct., and it was calculated that if the steam required during the process had been raised by means of a waste heat boiler, the efficiency of 46 p.ct. would have been increased to 56 p.ct.

The work described in this Seventh Report has been carried out at the Windsor Street Works of the Birmingham Gas Department with the object of determining the efficiency of production of carburetted water gas of a calorific value of about 485 B.Th.U. gross per cubic foot. At the same time, since the installation includes waste heat boilers, data have been procured showing the amounts of steam raised and the resulting increase in thermal efficiency of the whole process. Thermal and chemical balances which have been constructed have shown that the efficiency of production of blue water gas in the generators of the carburetted water gas plant, without taking into account steam required or raised, was 53 p.ct. Taking into consideration the differences in the methods of operation, this figure of 53 p.ct. is in agreement with the corresponding figure of 56 p.ct. given in the Sixth Report. The thermal efficiency of the whole process of manufacture of carburetted water gas of a calorific value of 485 B.Th.U. gross, taking into account the steam required for the generators and for driving the blower, exhausters, oil pump, and boiler feed pump, together with the steam raised in the waste heat boilers, averaged 68 p.ct. It has been calculated from the figures given in the balances that if the steam required had been raised externally in boilers with 70 p.ct. efficiency the efficiency of the whole process would have been only 59·5 p.ct., so that the waste heat boilers have brought up the overall efficiency by about 8·5 p.ct. The efficiency of production of oil gas (which did not lend itself to accurate determination) during the "cracking" of the enriching oil was approximately 90 p.ct.,* and it is this high efficiency which has caused the efficiency of the whole process to be so high as 68 p.ct. although the blue water gas was produced in the generators with a corresponding efficiency of only 53 p.ct. It is clear, therefore, that in stating the efficiency of production of carburetted water gas with a particular enriching oil it is necessary to state the quality of gas produced, for the overall efficiency will be dependent on the amount of oil gas admixed with blue water gas. With smaller quantities of oil than those used during the tests the overall thermal efficiency would have been lower than 68 p.ct., and would gradually have approached 53 p.ct. as the quantity of oil was reduced. With larger quantities of oil the efficiency of 68 p.ct. would increase so long as sufficient heat were available in the blow gases leaving the generators to heat up the carburettors and superheaters to an efficient "cracking" temperature.

The thermal balances of the waste heat boilers show that the total heat of the steam raised was only 41·9 p.ct. of

* This efficiency of 90 p.ct. is very near the oil efficiency previously obtained in tests of a carburetted water gas plant by A. G. Glasgow as described in a paper before the American Gas Light Association in 1890.

the heat entering the boiler during the first test, and the corresponding figures for the second and third tests were only 49·6 p.ct. and 43·4 p.ct. The amount of steam raised, however, in the first test was sufficient to supply the generators and to drive the blower and auxiliary plant; and in the other tests more than sufficient steam was raised. The low efficiencies of the boilers might be improved by more satisfactory means for burning the combustible gas leaving the superheaters during the blow periods, which would enable the production of larger quantities of steam so that more steam would be available if required for other purposes. The boilers were cleaned out by flushing with water every two or three months. For this purpose it was necessary to shut down the whole of the plant since there is no means of bye-passing the boilers during the operation of the plant. It would undoubtedly be an improvement if a convenient arrangement could be made which would enable the boilers to be shut down when necessary without interruption of gas-making. Before flushing with water, the boilers were allowed to cool several days in order to avoid strain of the fire tubes. No trouble was experienced from leakages of water between the fire tubes and the tube plates, but it is believed that absence of trouble from this cause was due to the care taken in cooling the boilers before cleaning. Trouble from leaky joints has been experienced in the case of some other installations, but this may well have resulted from allowing the boilers to cool only for a few hours before cleaning.

THE CARBURETTED WATER GAS INSTALLATION AT THE WINDSOR STREET WORKS OF THE BIRMINGHAM GAS DEPARTMENT.

The general arrangement of the carburetted water-gas installation at the Windsor Street works of the Birmingham Gas Department is shown in plan in Diagram I. The generator house contains four sets, each of a guaranteed capacity of one and a half million cubic feet per day, when using 4·3 gallons of oil per 1000 c.ft. of carburetted water gas made, and a generator fuel containing not more than 5 p.ct. moisture and a total ash and sulphur content of not more than 6 p.ct. on the dry basis. Each of the four sets, which are of the usual Humphreys and Glasgow pattern, consists of a blue water-gas generator followed by a carburettor, a superheater, and a wash-box; but, in addition, sets Nos. 3 and 4 include waste-heat boilers which were installed by Messrs. Humphreys and Glasgow in 1920. After passing through the scrubbers, the carburetted gas from sets Nos. 1 and 2 enters a common main by which it is conveyed to condensers before entering the exhausters. The gas from sets Nos. 3 and 4 enters another common main before passing in parallel streams through two sets of one scrubber and two condensers, after which these two streams again join before entering the exhausters. Throughout the tests described in this report only the two sets fitted with waste heat boilers were in operation. A more detailed description of these two sets and the corresponding auxiliary plant is therefore given.

Generator.—The generator, shown in horizontal and vertical sections in Diagram II., consists of a cylindrical steel shell lined with firebrick blocks, which are separated from the metal by annular spaces packed with non-conducting material. The bed of fuel rests on a flat bar grate on a level with which are clinkering doors, and below which is a door for removing the ashes and clinker into a pit immediately beneath. The generator is connected with the top of the carburettor by gas off-take pipes both above and below the fuel bed. During the "blow" periods the air enters the bottom of the generator, and the blast products travel through the outlet pipe at the top, and thence, through the carburettor, superheater, and waste-heat boiler, to the stack, which is controlled by a valve at the top. During the "run" periods, when the blast valve is closed, the steam enters either below or above the fuel bed, and the resultant blue water gas is carried away by the outlet pipe at the top or bottom of the generator according to whether the steaming is being operated in an upward or downward direction. The blue gas is then enriched with oil in the carburettor, whence it passes through the superheater into the wash-box, and thence to the scrubbers, condensers, and purifiers. Neither the blue gas nor the enriched gas is allowed to pass through the waste heat boiler. The generator is charged with coke through the door in the extreme top from metal hopper barrows fitted with adjustable distributing cones, the object of which is to distribute the fuel in the generator as evenly as possible.

The plant is manipulated from an elevated operating floor flush with the generator charging door, at which level all levers controlling the necessary valves are assembled. A battery of gauges indicating the pressures in the air-duct near the bottom of the generator, the generator base, carburettor top, superheater bottom, inlet wash box, and inlet condensers enables the operator to judge, at any stage of the process, the working conditions throughout the apparatus. Steam-meters, the indicator dials of which are also situated above the operating floor, enable the operator to regulate the steam valves to obtain the desired rate of flow of steam. In the blast main to the generator is fitted a Venturi meter, the differential pressure gauge of which is placed close to the indicator dials of the steam meters; so that an approximate control of the rate of air flow can be secured. An interlocking valve gear prevents the operation of the steam and blast valves except in their safe and proper order.

Air Supply.—When one, two, or three sets are in operation, the air required for the generators, carburettors, and superheaters is supplied by means of one of two No. 9 Sturtevant blowers, each driven by a 50 H.P. De Laval steam-turbine. When all four of the carburetted water gas sets are in operation at once, it is necessary to use both turbo-blowers.

Steam Supply.—The steam required for the generators, turbo-blowers, exhausters, boiler-feed pumps, and oil-feed pumps is obtained either from the waste-heat boilers or from Babcock and Wilcox water-tube boilers situated in the boiler house (Diagram I.), or from both sources according to the carburetted water-gas sets in use and the cycles of operation. In the tests described in this report, which were carried out only on the two sets with waste-heat boilers, the Babcock and Wilcox boilers were shut down and the steam required was obtained solely from the waste heat boilers.

Water Supply.—A supply of clear water of 8 degrees total hardness is obtained from an artesian well situated on the works. The water is first pumped to an elevated tank, whence it runs by gravitation to the wash-boxes, scrubbers, and condensers of the water-gas plant. In ordinary practice a quantity of the water which has been heated to about 140° Fahr. by passage through the condensers is run into a boiler feed-tank situated on the roof of the engine-house. This tank, which is rectangular in shape, has a total capacity of about 5000 gallons, and a capacity per inch of depth of 103·9 gallons. The waste heat boilers are fed by means of two Worthington "Duplex" pumps (one acting as a spare) of dimensions 5¼ in. by 3½ in. by 5 in.* During the tests, in order to ensure a more uniform temperature of supply, the well water was made to run by gravitation direct from the main tank to the boiler feed tank.

Carburettor.—From the generator the "blow" or "run" gases pass into the top of the carburettor, which consists of a cylindrical steel shell lined with firebrick blocks separated from the metal by annular spaces packed with non-conducting material. The carburettor is filled, according to usual practice, with chequer brick-work reaching to just below the level of the gas intake and supported on four firebrick pillars each about 9 in. diameter. The enriching oil is fed into the top of the carburettor through an adjustable spray-nozzle, which is protected by means of a firebrick cone as shown in Diagram II. Separate inlets, which are situated side by side at the top of the carburettor, are provided for the gas which is produced in the generator when steaming in upward and downward directions. An air-valve is also provided at the top of the carburettor for the admission of the requisite quantity of air during the "blow" periods to burn sufficient "blow" gas to heat up the carburettor and superheater to the temperature desired for "cracking" the enriching oil.

Oil to Carburettor.—The oil to the carburettor is supplied from one of three oil tanks (Diagram I.) by means of two (one acting as a spare) Blake twin-cylinder double-acting pumps, of dimensions 4½ in. by 3¾ in. by 4 in. The oil supply is regulated by special valves, and is measured by a meter of the positive type which is situated above the operating floor.

* Pump measurements are given in the usual order, (*i*) diameter of steam cylinder, (*ii*) diameter of oil or water cylinder, and (*iii*) length of stroke."

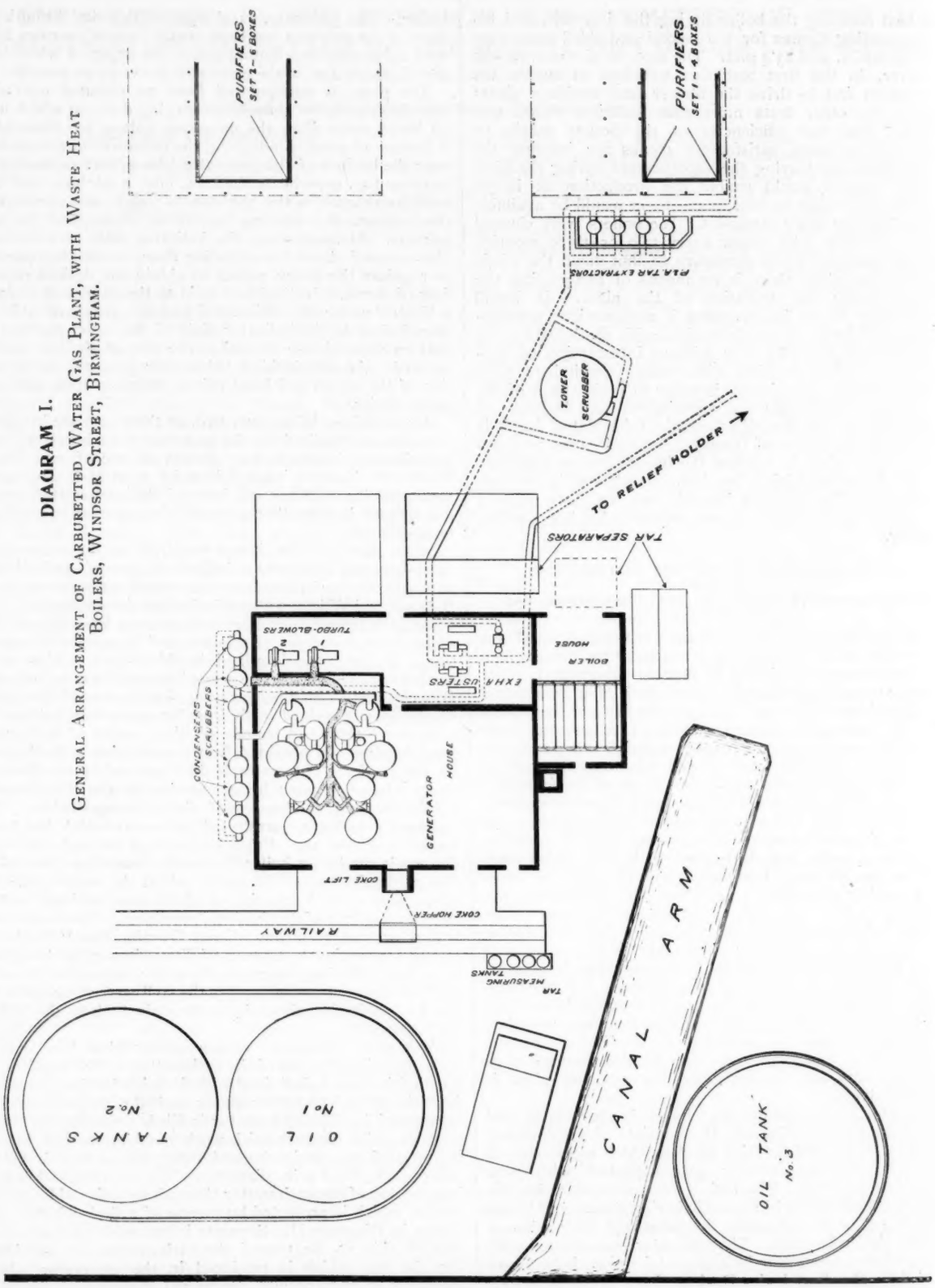
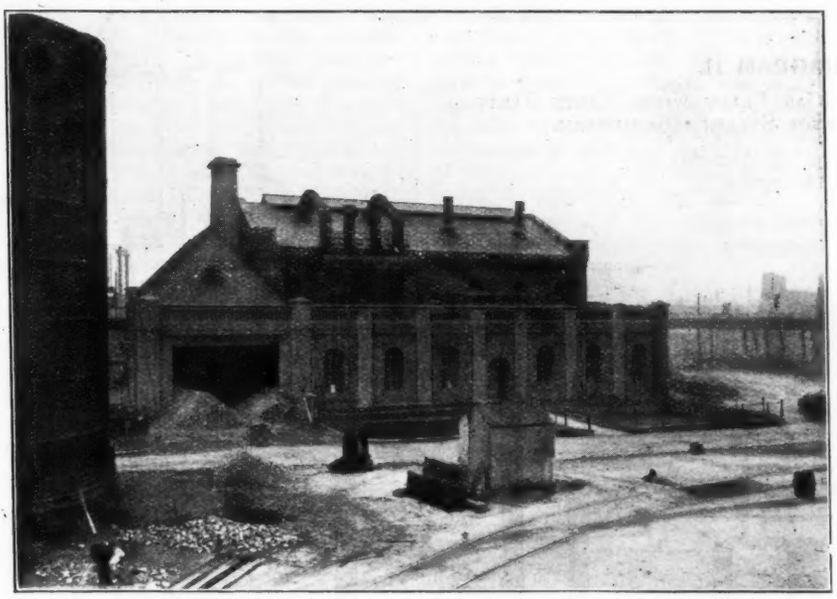


DIAGRAM I.

GENERAL ARRANGEMENT OF CARBURETTED WATER GAS PLANT, WITH WASTE HEAT BOILERS, WINDSOR STREET, BIRMINGHAM.

Superheater.—The superheater consists of a cylindrical steel shell lined with firebrick blocks and filled with chequer brickwork as in the case of the carburettor. By means of control valves, air may be admitted to the bottom and top of the superheater as required during "blow" periods, for the purpose of burning further quantities of gas. Much of the carbon monoxide, &c., remaining in the "blow" gas, after a sufficient quantity has been burned by the admission of air to the top of the carburettor and bottom of the superheater to heat up the carburettor and superheater to the required temperatures, may be burned by the admission of a further supply of air at the top of the superheater. By this means, potential heat which would otherwise be carried away up the stack by the "blow" gas, may be converted into sensible heat and rendered serviceable for raising steam in the waste-heat boiler.

Waste Heat Boiler.—The gas produced during the "blow" periods passes from the top of the superheater through a brick-lined pipe into a brick-lined chamber at the top of the waste-heat boiler. It then travels downwards through steel tubes into a chamber at the bottom of the boiler whence it enters the stack. The boiler is therefore of the fire tube type—*i.e.*, the hot gas travels through the tubes and the water is on the outside. The steel tubes, which are lapwelded, are supported by two end plates. The boiler is set at an angle to aid the



CARBURETTED WATER GAS HOUSE, WINDSOR STREET, BIRMINGHAM.

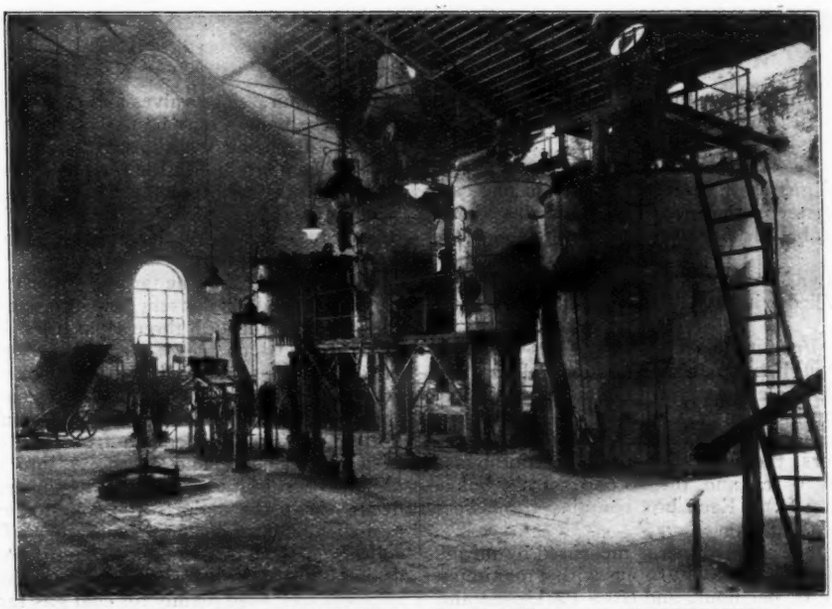
circulation of water, the level of which is kept well above the top plate supporting the steel tubes. Any sludge which collects may be "blown-off" periodically through the two "blow-off" cocks—the one situated at the bottom of the boiler and the other at the bottom of the lower circulating pipe connecting the boiler with the steam drum. The necessary manholes are provided, and the top cover is removable for the purpose of cleaning. The boiler is designed to raise steam up to a pressure of 100 lbs. per sq. in., and the fittings include the usual steam and water gauges and safety valve. Waste gas only is allowed to pass through the boiler, which is out of circuit during the "run" periods, when the carburetted water gas travels to the wash-box by means of a branch from the brick-lined pipe connecting the top of the superheater with the top of the boiler.

Wash-Box.—In the wash-box, the carburetted water gas travels through a water seal of about 2 in., which prevents the gas being forced back during the "blow" periods. The large area of the wash-box compared with the area of the dip-pipe enables this safety device to act at back pressures very much higher than the actual amount of seal in operation during the "run" periods. A continuous supply of water and an overflow ensure that the seal is kept at a constant amount.

Scrubbers and Condensers.—From the wash-boxes of the two sets with waste heat boilers the carburetted gas passes into a common main to a **T** piece, which divides it into two streams in parallel. Each stream travels in series through one scrubber and two condensers. In one case the scrubber is filled with chequer brickwork, and in the other with "Nielsen" patent "propeller" blocks. In each case, as the gas passes upwards through the scrubber it meets a stream of cold water flowing downwards and distributed evenly by means of sprays at the top. The water, tar, and emulsion flow out through a seal which is situated at the bottom of the scrubber. The gas is further cooled by means of the condensers which are of the water-tube type—*i.e.*, the water flows through the tubes and the gas on the outside. A quantity of the water which has been heated by passage through the condensers is ordinarily (but not during the tests) run into the boiler feed tank; the remainder being run to waste.

Exhausters.—When two machines are in operation, the carburetted gas from the condensers enters a common main before it is again divided into two streams in parallel through two rotary two-blade exhausters, each with a rated capacity of 100,000 c.ft. per hour.

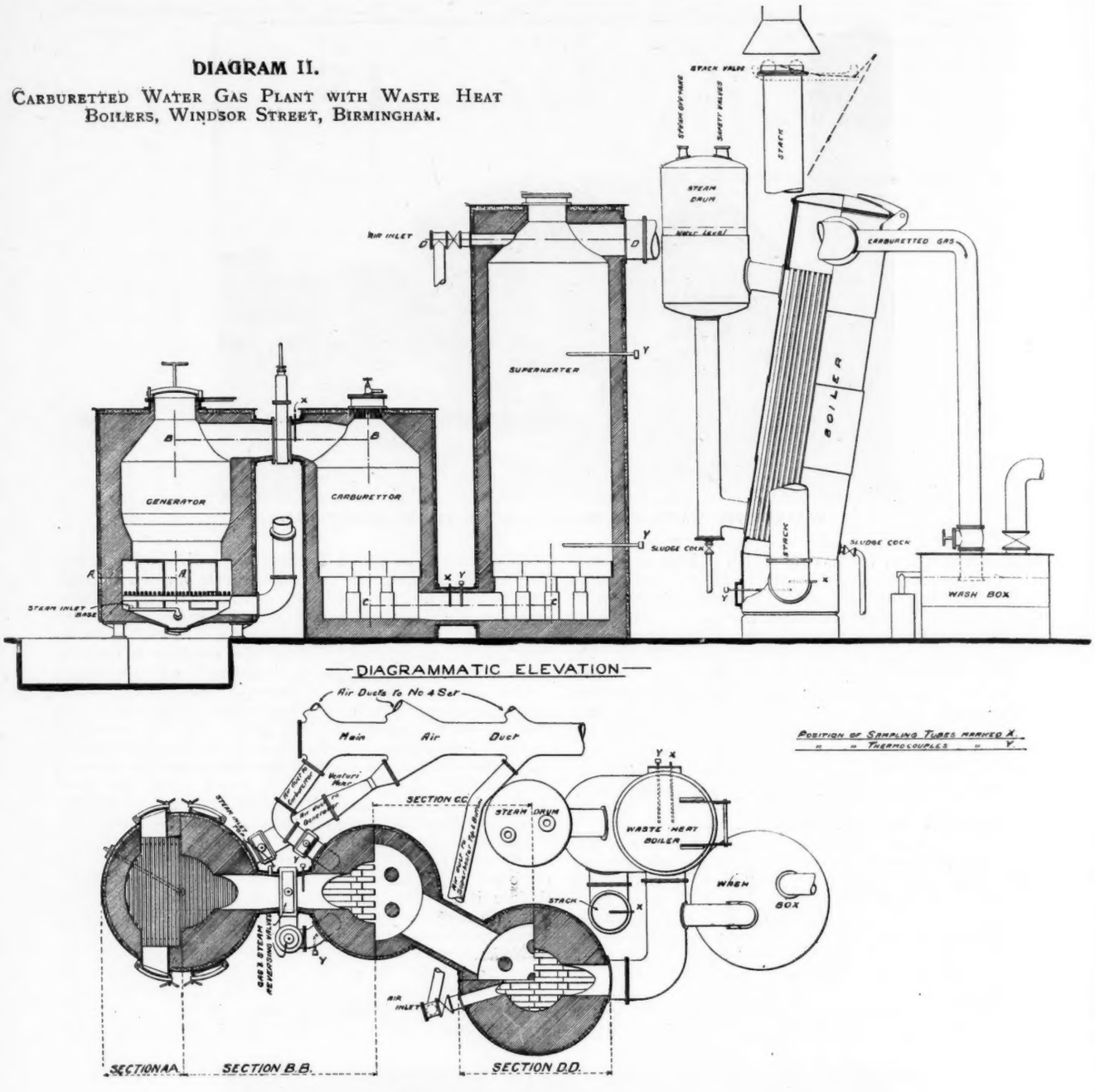
Relief Holder.—The relief holder, which consists of one cable-guided lift of a total capacity of approximately 100,000 c.ft., is situated as indicated in the plan (Diagram I.), from which it is seen that one main from the inlet to the exhausters serves as both inlet and outlet. The relief



OPERATING FLOOR; VIEW SHOWING STEAM DRUMS AND SUPERHEATERS.

DIAGRAM II.

CARBURETTED WATER GAS PLANT WITH WASTE HEAT BOILERS, WINDSOR STREET, BIRMINGHAM.



holder, therefore, compensates for any differences in the amount of gas made and the amount carried by the exhausters.

Air for Purification.—A small proportion of air is passed into the carburetted gas at the inlet exhauster in one case and the outlet exhauster in the other case by means of two small Roots blowers, belt-driven from the shafts driving the exhausters.

Coke Tower.—After leaving the exhausters, the gas passes up a tower filled with coke, in which tar and water separate out.

Tar Extractors.—From the coke-tower the gas travels in parallel streams through two or more of four Pelouze and Audouin tar and naphthalene extractors immediately before entering the oxide purifiers.

Purifiers.—The crude gas is purified by means of two sets of oxide purifiers, the first set containing four boxes (52 ft. by 24 ft. by 6 ft.) and the second set six boxes (40 ft. by 30 ft. by 6 ft.). Each box contains three tiers of oxide on flat grids.

Meters.—The make of purified gas is measured by means of two meters—(*i*) A Thorp's patent rotary with a maximum capacity of 150,000 c.ft. per hour, and (*ii*) a Parkinson and Cowan station meter with a maximum capacity of 100,000 c.ft. per hour. The valves and connections are so arranged that these meters may be used separately, in parallel, or in series. By using them in series the readings of one meter may be compared with the readings of the other; so that it is possible to calibrate the rotary meter with considerable accuracy. From the meters the purified carburetted gas passes into one of the large holders to mix with coal gas prior to distribution.

Tar Separators.—The tar and water from the wash-boxes, scrubbers, and condensers flow into one common main, and then in series through three separators (Diagram I.). These separators, which are all placed below ground level, consist of rectangular tanks each containing several dividing plates, so arranged that the water flows alternately under and over the plates and the heavier tar and emulsion collect at the bottom. The condensate from the coke-tower collects in a well beneath and overflows into a pipe which leads direct to the first separator. The tar and water which condense out in the main to the coke-tower are pumped over periodically into the first separator. The material which collects in the Pelouze and Audouin extractors, and which drains off from the purifiers, is ordinarily run into an adjacent well used mainly for coal gas tar.

Separation of Tar and Emulsion.—The tar and emulsion

are pumped periodically, usually each day, from the three separators into the tall cylindrical tanks marked "measuring tanks" in Diagram I. Each tank (Diagram III.), which is fitted with a steam-coil, has a total capacity of about 1200 gallons. The pumping is usually so arranged that most of the tar from the separators is delivered into one tank, whence it is allowed to flow from an outlet pipe at the bottom into a tar sales tank. The emulsion and tar remaining in the separators are pumped into another of the tall cylindrical tanks, where they separate into two layers, with the heavier tar at the bottom. The tar is first run off. The emulsion is then heated by passing steam through the coil for about eight hours, in order to recover as much tar as possible. After being allowed to cool overnight, recovered tar is run off until the line of demarcation of emulsion and water reaches the level of the water run-off pipe shown in Diagram III. The water is then allowed to flow away to waste, and the remaining tar is run into the tar sales tank. The emulsion is run into breeze, with which it is mixed, to be sold for use in specially-designed boilers.

PLANT ROUTINE.

The object of the investigation was to examine, from thermal and chemical standpoints, the process of manufacture of carburetted water gas as ordinarily practised. To avoid undue interference with the town supply, tests involving serious alterations in the methods of operation of the plant were not attempted.

During the first test described in this report the usual routine for the particular installation was adopted, except that the Roots blowers were shut down, so that no air was admitted for purification. The two carburetted water-gas sets Nos. 3 and 4, with waste-heat boilers, only were in operation. Clinkering was carried out on each machine every four hours, at 2 o'clock, 6 o'clock, and 10 o'clock on No. 3 set, and at 3 o'clock, 7 o'clock, and 11 o'clock on No. 4 set. The average time occupied was 16·1 minutes for No. 3 generator and 13·4 minutes for No. 4, or an overall average of 14·75 minutes for the two machines. The shorter average time required for No. 4 set is to be accounted for by the fact that the generator was in better condition, since it had just been re-lined. The routine of operation of each set was identical.

Immediately after clinkering, the fuel bed was subjected to a two minutes' "blow" followed by steaming in an upward direction for a few seconds. The direction of the flow of steam was then reversed, and downward steaming continued until the end of the third minute of the "run" period. The fourth and last minute of the "run" consisted of steaming in an upward direction. The complete cycle, which occupied six minutes, was therefore made up of two minutes "blow" and four minutes "run." The generator was then charged with coke to a depth of approximately 8 ft. 9 in. This occupied one minute, and was followed by five six-minute cycles before the generator was recharged with fuel. The five cycles were made up as follows:

1.—Two minutes "blow" and four minutes up "run."
2.—Two minutes "blow" and four minutes up "run."
3.—Two minutes "blow," three minutes down "run" and one minute up "run."
4.—Two minutes "blow" and four minutes up "run."
5.—Two minutes "blow" and four minutes up "run."

The complete period, including one "coking" and five six-minute cycles, therefore occupied 31 minutes; and since the approximate depth of the fuel bed immediately before coking was 7 ft. 3 in., the average depth was 8 ft. This 31-minute cycle of operations was carried out five times. The charging of the generator for the sixth time was followed by five six-minute cycles, each consisting of two minutes "blow" and four minutes steaming in an upward direction only. The seventh charging of the generator was followed by four or five similar six-minute cycles each including a two minutes "blow" and a four minutes up "run." When shutting-down for clinkering, the generator was charged with fuel after the last "run," and this was succeeded by a burning-off "blow" of two or three minutes, during which time air was admitted to the top of the carburettor only for the purpose of burning-off carbon deposit remaining in the carburettor and superheater. The required quantity of oil, which was 13 gallons per "run" throughout the tests described, was admitted to the carburettor at a uniform rate of flow during the first three minutes of each "run;" the oil valve being closed during the last minute.

It should be noted that the valves are so adjusted that steaming in an upward direction is compulsory immediately after a "blow" period. In those cycles including a three minutes down "run," the first up "run" occupied only sufficient time (usually about 20 seconds) to allow of the operation of the various valves.

Throughout the tests, the valves controlling the operation of the plant were manipulated in the following order when changing from "run" to "blow":

1.—Steam valve closed at the minute.
2.—Blast valve to generator opened.
3.—Stack valve opened.
4.—Air valve at top of superheater opened.
5.—Air valve at top of carburettor opened.

The time occupied in the complete operation of the valves from "run" to "blow" averaged 22 seconds.

Changing from "blow" to "run," the valves were operated in the following order:

1.—Steam valve opened at the minute.
2.—Blast valve to generator closed.
3.—Air valve at top of carburettor closed.
4.—Air valve at top of superheater closed.
5.—Stack valve closed.
6.—Oil valve opened.

The time occupied in operating the valves from "blow" to "run" averaged 18 seconds. The direction of steaming was changed by the movement of one lever only.

From the methods of operation as just described, it may be concluded that when changing from "run" to "blow" sufficient time elapsed after closing the steam-valve to allow a large proportion of the carburetted water gas in the machine to be swept forward to the wash-box before the stack-valve was opened. Similarly, changing from "blow" to "run" it would be concluded that the machine was purged of most of the "blow" gas between the opening of the steam valve and the closing of the stack valve. This conclusion has been supported by the results of analysis of samples of gas taken at several points at different times during the "blow" and "run" periods.

The times of the six minutes cycles of operations of the two machines were so arranged that during the "blow" periods of one machine gas making was in progress in the other, so that one turbo-blower was sufficient to provide the air required for both machines.

Throughout the tests, as in ordinary practice with the installation at the Windsor Street works, the air-valve at the bottom of the superheater was kept closed, so that no air was admitted at this point. The valve at the top of the carburettor was adjusted, during the "blow" periods, to admit an amount of air sufficient to burn the quantity of carbon monoxide, &c., required to maintain the carburettor and superheater at the desired temperatures, as indicated by the sight holes, test papers, and pyrometers, as described under the heading "Measurements of Pressures, Temperatures, &c."

During the first test the air-valve at the top of the superheater was adjusted according to the pressure of steam in the waste-heat boilers at the end of the "run." When the pressure was high, very little air was admitted; so that only a small quantity of the combustible gas remaining in the blow gas could be burned in the top of the superheater and the top of the boiler. A large amount of combustible gas was then carried away up the stack. With lower pressures, more air was admitted in order to transmit more heat to the boiler and thus raise the pressure of steam. It was endeavoured so to adjust conditions that the boiler pressure was 100 lbs. per sq. in. at the end of each "blow" period. Very little steam, therefore, was lost during the first test by escape through the safety valves of the boilers.

The method of operation of the two sets with waste-heat boilers was the same during the second and third tests as in the first test, except that the air-valve at the top of each superheater was opened to a set position (about three-quarters open, which is more than the average during the first test) during each "blow" period, irrespective of the pressure of steam in the boilers. Larger quantities of steam, therefore, were raised in the waste-heat boilers during the second and third tests; and since these quantities were greater than the total required for the generators, turbo-blowers, exhausters, oil pump and boiler feed pump, steam escaped through the safety valves. One Roots' blower was in operation during the second and third tests, for the purpose of supplying air for purification.

Measurements and Weighings.

Coke.—The coke used for the tests was obtained by the carbonization in continuous vertical retorts of coal from several different sources. During the process of carbonization, steam was admitted to the retorts in such quantities as to produce a coal gas of the required calorific value. The coke withdrawn from the retorts was conveyed direct to ferro-concrete hoppers, and thence to rotary screens of 2 in. mesh.

During the tests twelve trucks, marked "Test," were reserved solely for the purpose of conveying coke from the screens to the generator. Eight trucks were loaded early each morning; and these provided sufficient fuel, approximately 50 tons, to last more than twenty-four hours. The remaining four trucks served to keep the generators supplied during the loading, weighing, and sampling of the eight trucks. From the screens the trucks were conveyed to the weighing machines, which were carefully balanced each time before use; and the trucks were tared each time they were empty, before again being loaded. At the commencement of a test, the generators were charged with coke until the fuel beds reached a depth of 8 ft. 9 in. The whole of the coke afterwards charged into the generators was weighed, including the amount required to bring the fuel beds to the depth of 8 ft. 9 in. at the end of the test.

Ashes and Clinker.—The material withdrawn from the generators was stored until the end of each test. In the case of the first test this residue was carefully sorted by hand-picking and riddling into three parts—coke, breeze and ashes, and lump clinker. The three parts were then weighed and sampled separately, and the coke was afterwards used for the Babcock and Wilcox boilers. This hand-picking was carried out specially with the object of ascertaining the amount of fuel which could be recovered for use under these boilers. In the second and third tests, the lump clinker was picked out for convenience in sampling, and the ashes and clinker were weighed and sampled separately. The whole of the material withdrawn from the generators was then considered as waste, as in ordinary practice.

Air to Generators, Carburettors, and Superheaters.—The volume of air supplied to the generators during each test has been calculated from the composition of the "blow" gas leaving the generator and the amount of carbon consumed during "blow" periods as obtained from a carbon balance constructed for the generators alone. The total amount of air delivered to the generators, carburettors, and superheaters has been obtained from the composition of the waste gas passing up the stack, combined with the total carbon consumed during "blow" periods, as given by a carbon balance constructed for the whole process of manufacture of carburetted water gas. The difference between the total amount of air for the process and the amount used in the generators represents the volume supplied to the carburettors and superheaters. This method of calculation of air supply from carbon balances is believed to be more accurate, under the conditions of manufacture of water gas, than any known methods using Pitot tubes, Venturi meters, or anemometers.

Steam to Generators.—The steam to the generators was obtained by branch pipes from a main common to both waste-heat boilers, in which the pressure averaged 94 lbs. per sq. in. The maximum steam pressure of about 100 lbs. was obtained in the boilers at the end of each "blow" period—*i.e.*, the beginning of each "run." As the "run" proceeded, the pressure gradually fell to a minimum of about 88 lbs., after which it increased again to a maximum during the "blow." The valves controlling the supply of steam to the generators were adjusted to give the desired readings on the steam-meter gauges when the boiler pressure stood at 100 lbs. per sq. in. With the reduction in boiler pressure during each "run" period, there was a corresponding decrease in the amounts of steam passing through the nozzles of the steam-meters to the generators. That is to say, the amount of steam was automatically reduced with the fall in temperature of the fuel beds. Systematic readings of the steam-meter gauges were taken throughout the tests; and at the same time readings were taken of the actual pressures operating on the nozzles, as indicated by calibrated pressure gauges specially installed for the purpose of the tests. From the pressures operating on the nozzles and the results of calibrations, the amounts of steam delivered to the generators have been calculated and compared with the results of calculations from the volumes and compositions of the water gas made, coupled with the amounts of undecomposed steam.

Steam to Turbine.—Records were taken of the pressures of steam operating on the nozzles of the turbine during the "blow" and "run" periods. These figures combined with data supplied by the makers of the turbine (Messrs. Greenwood and Batley, Ltd., Leeds) have made possible the calculation of the steam consumption of the turbine.

Water to Boilers and Steam Raised.—The boiler-feed tank, which is rectangular in shape, was calibrated by direct measurement, and its capacity per inch of depth determined. The water supplied to the boilers was measured by means of a water-meter of the positive type, placed at the inlet to the tank. The meter was calibrated when the plant was shut down by first emptying the tank and then filling it with water passed through the meter. The actual amount delivered, ascertained from the known capacity of the tank, was compared with the readings of the meter index. In making calculations of the amounts of steam raised, the water supplied to the boilers was corrected for the water blown away through the "blow-off" cocks.

Oil to Carburettor.—The American petroleum gas oil used throughout the tests was drawn from Oil Tank No. 1 (Diagram I.), which was calibrated by direct measurement. The amount of oil in the tank at the beginning and end of each test was measured, and at the same time the average temperature was ascertained from samples withdrawn. The volume contained in the tank at each time of measurement was corrected to its equivalent volume at 60° Fahr. by means of a factor (0·00036 per degree Fahr.) obtained from determinations of the specific gravities of the oil at different temperatures. By comparing the volumes of oil used with the readings of the meters installed on the plant, it was found necessary to deduct 2·1 p.ct. from the meter readings to obtain the correct volumes.

Carburetted Water Gas Made.—The purified gas made during the tests was measured by the rotary meter which had previously been calibrated by passing gas in series for several hours through the wet meter and the rotary meter. Prior to this calibration, the wet meter had been checked by means of a standard test meter. Meter readings, together with pressures and temperatures, were taken at the beginning and end of each test. Similar readings were also taken several times each day during the tests. The state of the relief holder was observed at the beginning and end of each test, and corrections were accordingly made for the changes in the volume of gas in the holder.

Tar and Emulsion.—The tar measuring tanks (Diagrams I. and III.) were calibrated by direct measurements, from which tables were constructed showing the capacities of the tanks for each inch of depth. The amounts of tar and emulsion were then obtained from these tables from "dips" taken at the different stages of separation of tar, emulsion, and water.

The amounts of tar and emulsion which collected in the Pelouze and Audouin extractors and which drained off from the purifiers were obtained from the results of special experiments. These experiments were necessary, since the material collected at the points named did not flow back into the tar-separators. The capacities of the seal-pots of the extractors and of a small well in which the drainage from the purifiers collected were first determined by measurement. The seal-pots and well were then pumped until almost empty, and the amounts of tar and emulsion collected during different periods of time were measured. From the average of the results of these experiments, the amounts collected during the period of each test have been calculated.

Sampling.

Coke.—The coke supplied to the generators was sampled each day, immediately after it had been weighed, by taking small approximately equal quantities from each truck. The amounts taken were then mixed, broken up into smaller pieces and quartered down. The operations of crushing and quartering were continued on a special sampling plate until each sample of approximately 1 cwt. had been reduced in amount to about 1 lb. As soon as the powdered sample for each day had been made up it was immediately analysed for moisture. Finally, a sample was made up to represent the whole of the coke used in each test by taking from the sample for each day an amount in proportion to the weight represented, so that a composite

DIAGRAM III.
TAR MEASURING TANK.

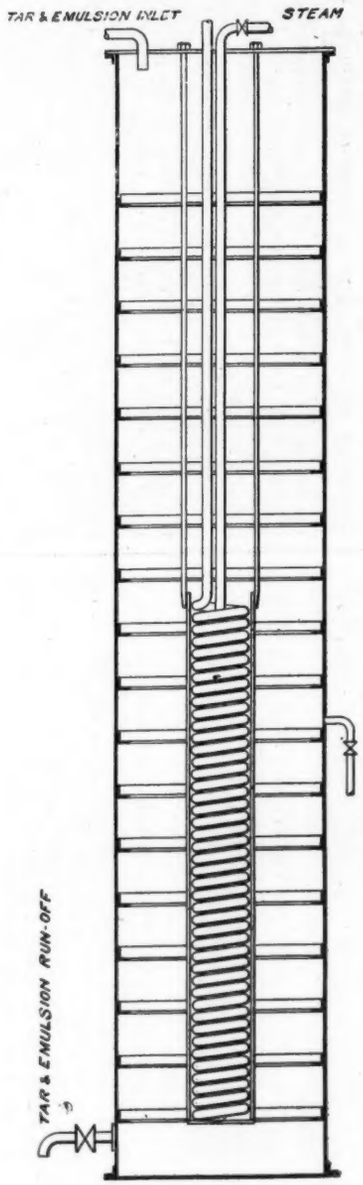
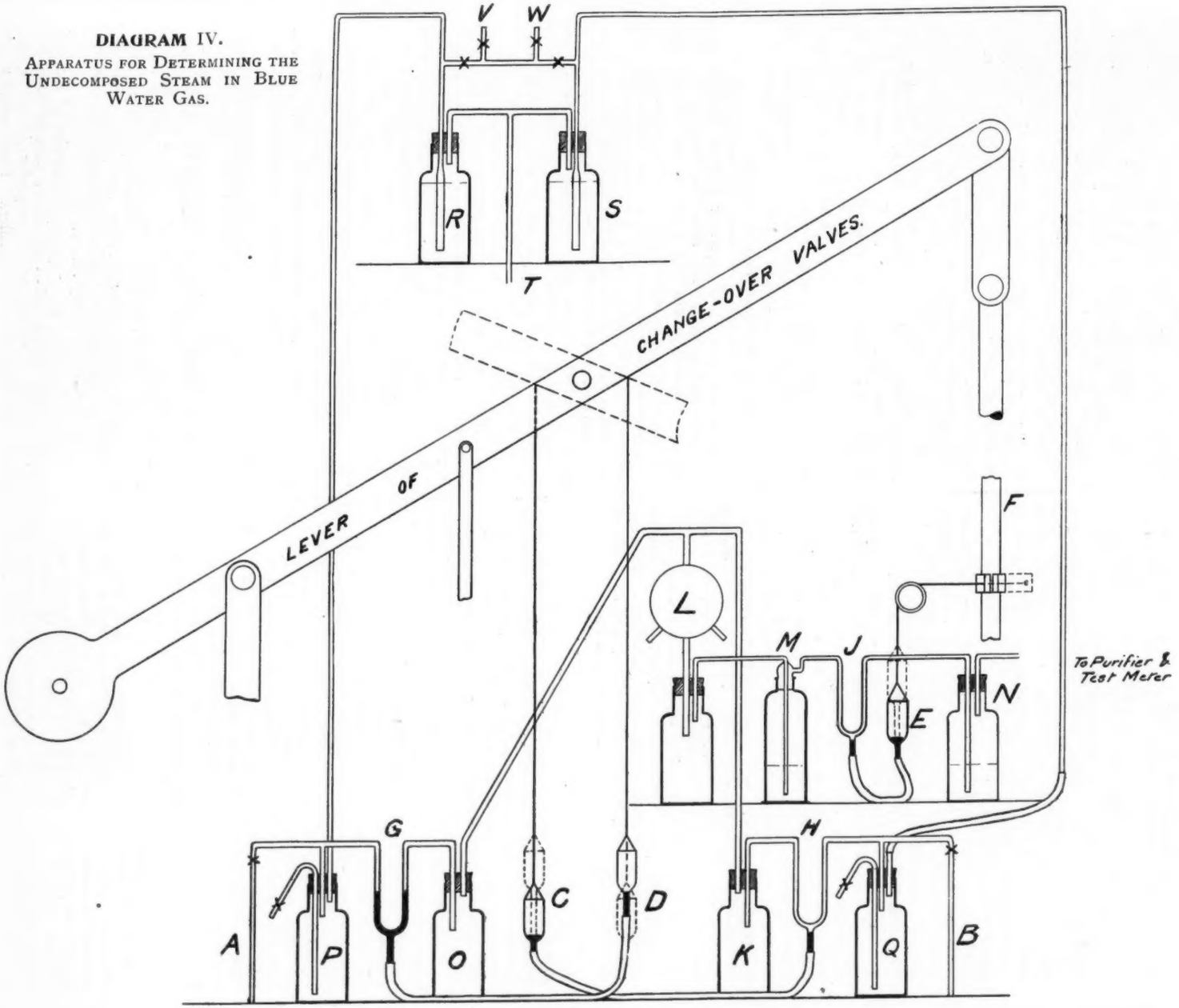


DIAGRAM IV.
APPARATUS FOR DETERMINING THE UNDECOMPOSED STEAM IN BLUE WATER GAS.



sample of about 1 lb. was obtained. The composite sample was then brought to a fine powder and used for the purpose of ultimate analysis and the determination of calorific values.

Ashes, clinker and coke recovered.—The ashes, clinker, and coke recovered were sampled separately when they were weighed at the end of each test. The samples were crushed and quartered down to about 1 lb., then finely powdered and used for analysis and calorific value determinations.

Oil to carburettor.—The enriching oil was sampled by drawing a definite quantity at regular intervals several times each day from a petcock placed on the side of one of the oil meters. The quantity drawn each time was such that when these amounts were added together, a composite sample of about 2 gallons was obtained to represent the oil used during each test. These samples were used for ultimate analyses and distillation tests.

Blue water gas.—Several times each day during the tests, average samples of the blue water gas made in each of the two generators were collected in glass aspirator bottles; these samples were used for purposes of analysis. Each sample was representative of the gas made during a complete coking to coking period of 31 minutes. Determinations were also made of the sulphuretted hydrogen content of the blue gas by means of standard iodine solution; and long period experiments were run for about 24 hours for the purpose of determining the amounts of undecomposed steam, naphthalene, cyanogen, and ammonia in the blue gas.

Owing to the intermittent nature of the process, it was necessary to carry out a number of preliminary experiments before a satisfactory method of conducting the longer period determinations could be obtained. When collecting samples over short periods of about half-an-hour it is possible to manipulate the taps of the sampling apparatus simultaneously with the movement of the valves of the plant during the changes from "blow" to "run" and *vice-versa*. But in the case of the long period experiments for the determination of the amounts of undecomposed steam, naphthalene, cyanogen, and ammonia, it was necessary to devise some automatic means of taking samples in such a way that the sampling was proceeding only during the "run" periods. After several trials, a very satisfactory apparatus was devised in which the control was obtained by means of mercury valves operated by the movements of the steam and change-over valves of the plant. One set of the apparatus was installed on the operating floor above each generator. The apparatus finally adopted for determining the amounts of undecomposed steam is shown in Diagram IV.

The tubes A and B (Diagram IV.) are in direct connection with silica sampling tubes passing into the two gas delivery pipes at the inlet to the carburettor (Diagram II.). Samples of the gas passing through the bottom outlet of the generator travel through A and samples of the gas from the top outlet through B. When steam is being passed in an *upward* direction through the generator, the lever of the change-over valve occupies the position shown in Diagram IV. The reservoirs of mercury C and D are supported by cords of adjusted lengths connected with the change-over lever; and the reservoir E is connected by means of a cord over a pulley wheel with the safety rod F. These reservoirs are then in such positions that the U tube G is sealed with mercury, but there are free passages through the U tubes H and J. During steaming in an *upward* direction, therefore, a sample of the blue water gas made travels through (1) the sampling tube B, (2) the U tube H, (3) the bottle K in which some of the undecomposed steam condenses, (4) the water-cooled metal ball condenser L, (5) the Drechsel bottle M containing concentrated sulphuric acid to absorb water vapour not previously condensed, (6) the U tube J, and (7) the bottle N containing water to saturate the gas again before it passes through an oxide purifier and is measured in a calibrated test meter.

When the steaming is being operated in a *downward* direction, the lever of the change-over valve and the mercury reservoirs C and D occupy the positions denoted by the dotted lines, with the result that there is a free passage through the U tube G, while the U tube H is sealed with mercury. The mercury reservoir E retains the position shown by plain lines throughout each "run" whether the steaming is being carried out in an upward or downward direction. During *downward* steaming, therefore, the sample travels through the tube A, the U tube G, the bottle O, in which some of the undecomposed steam is condensed, the water-cooled condenser L, the Drechsel bottle M and so to the purifier and meter as in the case of upward steaming

On changing from "run" to "blow," as the steam valve is closed the safety rod F moves through a right-angle, with the result that the reservoir E is lifted to the position denoted by dotted lines and the U tube J is sealed with mercury. This has the effect of preventing any gas from passing through the condensing apparatus during "blow" periods. The bottles P, Q, R and S are arranged in such manner that rapid streams of hot gas pass through the tubes A and B during both the "blow" and "run" periods, so that these tubes are kept hot and free from condensed moisture. Further, the arrangement ensures that the samples measured during the "run" periods are drawn off from rapid continuous streams. The water seal devices in the bottles R and S also ensure that there is sufficient pressure to maintain the sampling stream. The excess gas is carried away to waste through the tube T.

By means of the branch tubes V and W, samples of "blow" and "run" gases for purposes of analysis were collected as desired in glass aspirator bottles or in other sampling apparatus. Samples were also taken from these points for the determinations of the sulphuretted hydrogen content of the blue water gas and the sulphur dioxide content of the "blow" gas. Determinations of the naphthalene, cyanogen and ammonia contents of the blue water gas were made by replacing the Drechsel bottle M by the absorption bottles required in the respective cases.

Blow gas.—Several times each day during the tests, average samples of the "blow" gas at the inlet to the carburettors were taken in the manner described in the paragraphs explaining the methods of sampling the blue water gas; these samples were used for analysis in an Orsat apparatus and a Bone and Wheeler gas analysis machine. The sulphur dioxide content of the "blow" gas was determined by passing the gas through two wash bottles containing standard iodine solution followed by a catch bottle of potassium iodide solution.

Samples of the gases entering the waste heat boilers were drawn into glass aspirator bottles, through silica tubes inserted in the position shown in Diagram II. These samples, however, did not prove to be entirely satisfactory, since it was found by observation through a sight hole placed in the top chamber of each boiler that combustion was still taking place with production of a pale blue flame. Analysis led to the conclusion that the gases must have changed in composition during passage through the silica tubes, not merely as a result of further reaction between the gases themselves, but also by interaction with particles of hot carbon deposited in the sampling tubes. It is evident from observation through the sight hole at the top of each boiler and from the compositions of the gas samples collected at these points and at the outlet chambers of the boilers, that improvements could be made in the arrangement for burning the combustible gas in the "blow" gases leaving the superheaters. It would appear that after sufficient air has been admitted to combine with the whole of the combustible gas in the "blow" gases leaving each superheater, the mixture requires to be passed through a chamber so designed that combustion would be completed before the gases enter the top chamber of the boiler. With the plant as designed at present the gases enter the boiler tubes before the reactions have been completed and are cooled below the temperatures required for combustion.

Waste gas.—Average samples of the waste gases carried away into each stack were drawn into glass aspirator bottles through silica tubes inserted in the base of each stack in the position shown in Diagram II. Each sample reserved for analysis was representative of the waste gas produced during a complete coking to coking period. Several experiments were also carried out, in which the waste gas was drawn through tubes containing cotton wool and calcium chloride, in order to determine the amount of moisture carried away up the stack.

Carburetted water gas.—Average samples of the purified gas made during each eight hours were collected in a sample holder of about 200 c.ft. capacity, by means of a branch pipe from the outlet purifiers. These samples were

used for analysis and for determinations of calorific values and specific gravities.

The sulphuretted hydrogen content of the crude carburetted water gas at the outlet exhausters was determined by passing measured quantities (usually about one-tenth of a cubic foot) through two wash bottles containing standard iodine solution followed by a catch bottle of potassium iodide solution. The gas was passed at a slow rate so that each experiment occupied about 40 minutes. Several such determinations were made during each 24 hours of the tests. With the object of determining the amount of correction to be applied to the results to allow for any iodine absorbed by hydrocarbons, a number of similar experiments were carried out with the purified gas at the inlet to the rotary meter. The amount of correction, however, was found to be so small that it could be neglected, being equivalent to only about 2 grains of sulphuretted hydrogen per 100 c.ft. It is worthy of note that in similar determinations with coal gas, much larger corrections of the order of 20 grains per 100 c.ft. are frequently required, since larger quantities of iodine are absorbed by the hydrocarbons in coal gas.

Special experiments were also run for longer periods for the determination of the amounts of naphthalene, cyanogen and ammonia in the gas at the outlet exhausters. In addition, determinations were made of the undecomposed steam accompanying the carburetted gas at the inlet to the wash-boxes.

It should be noted that all samples of gas whether for gas analysis or long period experiments were taken off by branch pipes from rapid continuous streams.

Tar and emulsion.—Each time during the tests that tar was run out of one of the measuring tanks (Diagrams I. and III.), a sample was collected in a 1-gallon can by running a thin stream from a petcock on the delivery pipe. A composite sample of about 3 gallons for the whole test was then made up by mixing together amounts from the 1-gallon samples in proportion to the volumes represented. The emulsion run off from the measuring tanks was sampled in a similar manner.

Samples of the tar and emulsion which deposited in the Pelouze and Audouin extractors, and which drained off from the purifiers, were taken at the time of the experiments carried out to determine the amounts collected at these points.

Measurements of Pressures, Temperatures, &c.

Throughout the tests the following readings on each set were systematically recorded every few hours :

(1) The pressures in inches of water during the "blow" and "run" periods as indicated by the battery of gauges above the operating floor; (*a*) air-duct, (*b*) generator base, (*c*) inlet carburettor, (*d*) inlet superheater, (*e*) inlet wash-box, and (*f*) inlet condensers.
(2) The readings, during "blow" periods, of the differential gauge of the Venturi meter in the blast main.
(3) The pressures of steam in the waste-heat boiler.
(4) The pressures of steam in lbs. per square inch operating on the nozzles of the steam-meters during the "run" periods, as indicated by the calibrated pressure gauges specially installed.
(5) The pounds of steam delivered per minute, as indicated by the gauges supplied with the steam-meters.
(6) The pressures of steam on the nozzles of the turbine during the "blow" and "run" periods.
(7) The pressure of gas at the outlet of the exhausters.
(8) The temperatures of the superheater as indicated by the calibrated iron-constantan thermo-couples installed in the positions shown in Diagram II.

TABLE I.—*General Results of Tests.*

Test No.	1.	2.	3.
Depth of fuel bed in feet (average)	8	8	8
Duration of test in hours	112·17	114·58	72·17
Time of clinkering in hours	6·88	7·93	4·86
Time of gasification in hours, including "blow" and "run" periods.	105·29	106·65	67·31
Coke (wet) supplied to generators in tons	234·64	234·40	148·66
Moisture in coke per cent.	5·3	4·1	5·6
Coke (dry) supplied to generators in tons	222·20	224·79	140·34
Oil supplied to carburettors in gallons (corrected to 60° Fahr.)	25,600	25,495	16,497
Oil to carburettors in gallons per ton of coke to generators	115·21	113·41	117·55
Total carburetted gas (purified) made in cubic feet (60° Fahr. and 30 in.).	14,018,000	13,929,000	8,900,000
Carburetted gas in cubic feet per ton of coke to generators	63,090	61,960	63,420
Coke in lbs. to generators per 1000 c.ft. C.W.G.	35·51	36·15	35·32
Oil to carburettors in gallons per 1000 c.ft. C.W.G.	1·826	1·830	1·854
Carburetted gas in cubic feet made per day per machine	1,500,000	1,459,000	1,480,000
Carburetted gas in cubic feet made per hour of gas making per machine	66,570	65,300	66,110
Composition of C.W. gas—volume per cent.: CO_2	5·2	5·5	5·2
C_mH_n	5·8	5·9	6·0
O_2	0·1	0·5	0·4
CO	34·9	34·3	34·9
H_2	38·1	38·2	38·6
CH_4	10·3	9·8	10·0
N_2	5·6	5·8	4·9
	100·0	100·0	100·0
Inerts, including oxygen.	10·9	11·8	10·5
"True" inerts	10·4	9·4	8·6
Specific gravity of gas (air = 1)	0·64	0·63	0·63
Calorific value of gas in B.Th.U. per cubic foot gross.	484	481	485
" " " " " " " net	446	443	448
Thermal value of gas in therms gross per ton of coke.	305·3	298·0	307·6
" " " " " net " "	281·4	274·5	284·1
Thermal value of gas made per machine per day in therms gross	7,258	7,017	7,177
" " " " " " " " " " net	6,688	6,462	6,630
Sulphuretted hydrogen in grains per 100 c.ft. in gas at outlet exhausters.	173	186	169
" " " " volume per cent. " " "	0·28	0·30	0·27
Sulphur in grains per 100 c.ft. in purified gas	13·3	13·3	13·3
Dry coke recovered for boilers in tons per ton of coke to generators	0·042	..	..
Dry ashes withdrawn in tons per ton of coke	0·056	0·113	0·118
Dry clinker " " " " "	0·049	0·037	0·032
Water evaporated in waste heat boilers in lbs. per 1000 c.ft. C.W.G.	60·55	69·88	61·11
Equivalent evaporation in lbs. from and at 100° C.	69·01	79·75	69·92
Tar (dry)—			
Gallons in tar recovered per 100 gallons oil	11·60	12·60	10·90
Gallons in emulsion " " "	1·42	1·42	1·07
Gallons from P. and A. extractors per 100 gallons oil	1·39	1·42	1·39
Gallons from purifier boxes and pipes per 100 gallons oil	0·62	0·64	0·62
Total amount of dry tar per 100 gallons of oil	15·03	16·08	13·98
Gallons in tar recovered per 1000 c.ft. C.W.G.	0·212	0·231	0·202
Gallons in emulsion " " "	0·026	0·026	0·020
Gallons from P. and A. extractors per 1000 c.ft. C.W.G.	0·025	0·026	0·026
Gallons from purifier boxes and pipes per 1000 c.ft. C.W.G.	0·011	0·012	0·011
Total amount of dry tar in gallons " " " "	0·274	0·295	0·259

(9) The temperature of the waste gases leaving the waste-heat boiler, as indicated by the calibrated iron-constantan thermo-couple placed in the outlet gas chamber.

(10) Temperatures by means of mercury thermometers; (*a*) air at inlet generator, (*b*) carburetted water gas at inlet to condensers, and (*c*) carburetted water gas at outlets of condensers.

(11) Index readings of the rotary gas-meter and of the experimental test-meters, together with their respective temperatures and pressures.

(12) Index readings of the meter measuring the water supplied to the boiler-feed tank, together with the temperature and depth of water in the tank.

(13) Readings of the oil-meters, together with temperatures.

(14) The depth and temperature of the oil in the supply tank, and the pressure of oil at the outlet of the oil-pump.

The average temperatures of the "blow" and "run" gases at the outlets of the generators and the inlets of the superheaters were deduced by combining the readings taken during the tests with the results of investigations made at other times under the same conditions of operation of the plant.

Special investigations were also carried out to determine the corrections to be applied for the "lag" of the pyrometers placed in the outlet gas-chambers of the waste-heat boilers. The intermittent nature of the process, and the consequent rapid changes in the temperatures of the gases produced, rendered these special investigations absolutely necessary. Without extraordinary precautions even approximate readings cannot be obtained, and it is certainly impossible to obtain temperature readings sufficiently accurate to be used in the construction of thermal balances. For example, using the usual pattern of iron-sheathed iron-constantan thermo-couple, the average of the temperatures of the gases leaving the waste-heat boilers during the "blow" periods was approximately 60° C. lower than the average temperature obtained under similar conditions with a bare platinum-platinum rhodium couple. This discrepancy was due entirely to the difference in the "lag" of the pyrometers. Attention is therefore specially directed to Section II. of this report, in which the subject is more fully discussed, and the results of the investigations on temperature measurement are given in further detail.

Details of Tests.

The principal results of the three complete tests carried out are given in Table I., in which various items are reported in amounts per ton of dry coke to the generators, per 1000 c.ft. of carburetted water gas made, and per 100 gallons of enriching oil used. In general the differences in the results of the three tests are not important. Where differences do occur they may be accounted for on consideration of the relative conditions of the plant at the time of the tests and of the ratio of delivery of air and steam to the generators and air to the carburettors and superheaters. The plant was in the best condition during the first test, which lasted nearly five days. During the second and third tests the condition of the carburettor of No. 4 set was relatively poor; but it was decided to carry out these tests before rebuilding the chequer brickwork in order to ascertain whether the poorer state of the carburettor had any marked effect on the results obtained, and, further, it was believed that the average figures deduced from all three tests would more nearly represent the performance of the plant under ordinary conditions. The second test occupied nearly five days, but the third occupied only three days. It was intended that the third test should extend over the same length of time as the first and second, but it was necessary to stop this test after three days owing to the commencement of a leakage of gas from the saddle joint at the T piece situated between the top of the superheater and waste-heat boiler of No. 4 set. It will be remembered from the description of the plant that the gas produced during "blow" periods travels through a brick-lined pipe connecting the superheater with the inlet gas chamber at the top of the waste-heat boiler. During the "run" period, however, the carburetted gas, which leaves the superheater by the same brick-lined pipe, does not enter the waste-heat boiler but travels by a branch to the wash-box. This branch was not brick-lined, so that during "blow" periods the saddle joint was directly exposed to the flame of burning gases, with the result that trouble has frequently been caused by the "burning-out" of the branch at or near the joint. The branches on both sets have been repaired several times by arc-welding, but since the tests were carried out a larger brick-lined branch has been installed on No. 4 set, and it is believed that the alteration will prevent further trouble from this cause.

During the first test the plant was operated in the same manner as that adopted in ordinary practice, the air valve at the top of each superheater being opened to an extent sufficient to admit the air required for burning the quantity of combustible gas which would raise (as far as possible) the pressure of steam in the waste-heat boilers to 100 lbs. per sq. in. at the end of each "blow." Very little steam, therefore, escaped through the safety valves during the first test, so that it may be considered that the steam raised during this test was approximately equal to the amount required to supply the generators and for driving the turbo-blowers, exhausters, oil pump, and boiler-feed pump. The method of operation of the plant was the same in the second and third tests as in the first test, except that the air valve at the top of each superheater was opened to a set position (about three-quarters open) during each "blow" period; and any steam raised in excess of the quantity required for the generators, turbo-blower, and auxiliary plant was allowed to escape through the safety valves.

The times occupied in clinkering, which was carried out on each machine every four hours, were comparatively short, averaging only 14.75, 16.6, and 16.2 minutes for each clinker period in Tests 1, 2, and 3 respectively; and these average times include the one or two minutes which were necessarily lost on many occasions in arranging that the "blow" periods on one set did not coincide with the "blow" periods on the other set.

The carburetted water gas made during the three tests contained an average of 5·3 p.ct. carbon dioxide, 5·9 p.ct. unsaturated hydro-carbons, and 34·7 p.ct. carbon monoxide. The hydrogen content averaged 38·3 p.ct. and methane 10·0 p.ct. It should be pointed out that the gas analyses were carried out by the usual method, which does not give strictly accurate figures for hydrogen and methane, although the results obtained are useful for comparative purposes. By the usual method of analysis any hydro-carbon gases not absorbable by bromine are returned as methane, although undoubtedly they include other higher hydro-carbons such as ethane. These higher hydro-carbons cause an expansion in volume during combustion over copper oxide, with the result that the hydrogen figure is low, and the methane figure really represents the volume of methane containing the same amount of carbon as the hydro-carbons remaining in the gas at this stage of the analysis. In any case it gives the correct carbon content for use in the construction of carbon balances, and the results are comparable with those ordinarily obtained in the industry. The gross calorific values of the gas made in the three tests were respectively 484, 481, and 485 B.Th.U. per cubic foot, as determined by means of a water flow calorimeter of the Junker type. The corresponding net calorific values determined were 446, 443, and 448 B.Th.U. per cubic foot.

The volume of purified carburetted water gas made per machine per day in the tests described in this report averaged 1,480,000 c.ft. The quantity of dry coke supplied to the generators per 1000 c.ft. of carburetted water gas made averaged 35·66 lbs. These gas-making results of the tests were obtained without overdriving the plant and without undue detriment to the generator linings, carburettor, and superheater chequer brickwork or plant fittings.

The inerts contained in the gas made are given against two items, the first including carbon dioxide, oxygen and nitrogen; and the figures against the second item described as "true" inerts have been obtained by deducting the air equivalents of the oxygen contents from the figures against the first item.

The thermal values of the gas made per machine per day are included in Table 1, since these figures are now of the same order of importance as the yields of gas in cubic feet; the gross thermal values of the gas made per machine per day during the tests averaged 7151 therms.

Determinations of the sulphuretted hydrogen in the blue water gas at the outlets of the generators gave average figures of 285 grains per 100 c.ft. in Test 1, 300 grains in Test 2, and 280 grains in Test 3. These figures average

288 grains per 100 c.ft. Assuming that the total amount of sulphuretted hydrogen leaving the generators remained unchanged during the enriching process in the carburettors and superheaters and that the volume of blue gas made was 84 p.ct. of the carburetted gas, then the sulphuretted hydrogen content of the crude carburetted gas should be 242 grains per 100 c.ft.; whereas the amount actually found was only 176 grains. The difference between the figure 242 grains and the amount found, 176 grains, was probably due to the decomposition of sulphuretted hydrogen in the carburettors and superheaters. It was found, as in the tests with blue water gas at Adderley Street, that the blue gas produced during up "runs" contained more sulphuretted hydrogen than that produced during down "runs."

The sulphur content of the purified carburetted water gas is given as 13·3 grains per 100 c.ft. for all three tests; this figure is the average of experiments carried out at different times when the conditions of operation of the plant were the same as those during the tests. It was found that the sulphur content did not vary very much provided the purifiers were in good condition.

As already explained, the coke recovered in Test 1 was obtained by hand-picking and riddling which was done by way of experiment. It is not the usual practice with this installation.

The amounts of water evaporated in the waste-heat boilers are given, together with the equivalent evaporations from and at 100° C. in lbs. per 1000 c.ft. of carburetted water gas made. The amount of water evaporated in Test 1, 60·55 lbs. per 1000 c.ft. of gas, was just sufficient to meet the requirements of the generators, turbo-blower, exhausters, oil pump and boiler feed pumps. More steam could have been raised in this test by the admission of a larger quantity of air to the top of the superheaters.

The amounts of dry tar obtained per 100 gallons of enriching oil used are set out in five items. The figures against the first item represent the dry tar content of the tar recovered, of which about one-eighth was obtained by steaming emulsion. The second item gives the amounts of dry tar in the emulsion remaining after steaming. The third item represents the amounts of dry tar in the tar and emulsion which collected in the P. and A. extractors, and the fourth item gives the amounts in the tar and emulsion which drained from the purifier boxes and pipes. The total amounts of dry tar are shown in the fifth item. The corresponding yields per 1000 c.ft. of carburetted water gas are also included.

Experiments carried out for the determination of amounts of naphthalene gave an average value of 0·33 grains per 100 c.ft. in the blue water gas leaving the generators. Although the naphthalene content of the purified carburetted gas was less than 1 grain per 100 c.ft. during the time of the tests (in winter), the average amount in the crude carburetted gas sampled at the outlet of the exhausters was found to be 14·7 grains at an average temperature of 18·6° C. (65·5° Fahr.). This is a high figure, for it is probably more than the amount required for the naphthalene saturation of the gas at this temperature.* It is quite possible that the naphthalene found in the carburetted gas at the outlet exhausters was not present entirely as vapour, but included solid particles in the form of a cloud. This is a probable explanation since the large quantities of naphthalene in the tar recovered lead to the conclusion that the hot carburetted gas contained even larger quantities of naphthalene, much of which separated out during the passage of the gas through the condensers and mains. As the cloud precipitated, the naphthalene deposited would be carried away with condensed tar. The problem undoubtedly justifies an investigation which should also aim at ascertaining the effect of the "cracking" temperature of the oil on the production of naphthalene.

The average amount of ammonia in the blue water gas leaving the generators was found to be 2·9 grains per 100 c.ft., and in the carburetted water gas at the outlet of the exhausters the average content was about 0·1 grain. The cyanide contained in the blue water gas as determined by the ferrous hydrate method (*vide* Appendix I.) was equivalent to 0·029 lb. of crystalline sodium ferrocyanide per 10,000 c.ft., and in the crude carburetted water gas the cyanide was equivalent to 0·01 lb. of crystalline sodium ferrocyanide per 10,000 c.ft.

Compositions of gases (*Table II.*).—The average compositions of the purified carburetted water gas made, the blue water gas and "blow" gas leaving the generators, and the waste gas leaving the waste-heat boilers are given in Table II., in which the corresponding calorific values are

* J. S. G. Thomas (J. Soc. Chem. Industry, 1916, 506) found that dry coal gas, after passing over naphthalene at 18·6° C., contained approximately 15 grains per 100 c.ft.; wet coal gas contained only about 7·5 grains.

TABLE II.—*Analysis of Gases.*

Gas	Blue Water Gas.			Carburetted Water Gas.		
Test No.	1.	2.	3.	1.	2.	3.
Composition—volume per cent. CO_2	6·1	6·4	5·9	5·2	5·5	5·2
C_mH_n	0·0	0·0	0·0	5·8	5·9	6·0
O_2	0·1	0·1	0·1	0·1	0·5	0·4
CO	38·3	38·2	38·8	34·9	34·3	34·9
H_2	50·9	52·2	51·8	38·1	38·2	38·6
CH_4	0·5	0·5	0·5	10·3	9·8	10·0
N_2	4·1	2·6	2·9	5·6	5·8	4·9
	100·0	100·0	100·0	100·0	100·0	100·0
Calorific value in B.Th.U. per cubic foot (saturated, 60° Fahr. and 30 in.)—						
Gross	290	293	294	484	481	485
Net	263	267	267	446	443	448
Gas	"Blow" Gas. (Sampled between Generator and Carburettor.)			Waste Gas. (Outlet Gas Chamber of Waste Heat Boiler.)		
Test No.	1.	2.	3.	1.	2.	3.
Composition—volume per cent. CO_2	11·6	11·6	12·2	16·7	17·1	16·7
C_mH_n	0·0	0·0	0·0	0·0	0·0	0·0
O_2	0·0	0·1	0·1	0·4	0·9	1·2
CO	14·3	14·3	13·7	4·5	2·8	3·0
H_2	2·5	2·6	2·9	1·6	0·6	1·2
CH_4	0·2	0·2	0·3	0·3	0·4	0·5
N_2	71·4	71·2	70·8	76·5	78·2	77·4
	100·0	100·0	100·0	100·0	100·0	100·0
Calorific value in B.Th.U. per cubic foot (calculated)—						
Gross	55·5	55·8	55·8	22·4	14·8	18·3
Net	54·0	54·3	54·0	21·3	14·1	17·2

NOTE.—The calorific values given for carburetted water gas are the results of determinations. The calorific values of the other gases have been calculated from the data in Appendix II.

also included. The compositions of the blue water gas fall into line with the compositions of the carburetted gas in that the carbon dioxide contents in both cases are higher in Test 2 than in Tests 1 and 3. The relative agreement in the carbon dioxide contents is shown by the ratios of the amounts of this constituent in the carburetted gas to the amounts in the blue gas which are approximately the same in the three tests, being respectively 85 p.ct., 86 p.ct., and 88 p.ct., or an average ratio of about 86 p.ct. The fact that the quantities of nitrogen in the blue water gas are relatively small results from the difficulty in so adjusting the sampling that the quantity of "blow" gas included exactly corresponds with the amount carried forward in the carburetted gas.

The compositions of the "blow" gas in Tests 1 and 2 are almost identical, but in Test 3 the "blow" gas contained a little more carbon dioxide and proportionately less carbon monoxide. From a number of determinations of the sulphur dioxide content of the "blow" gas leaving the generators, it was found that the average amount was equivalent to 66 grains of sulphur per 100 c.ft.

The compositions of the waste gases show that, although in each test a certain amount of carbon monoxide, hydrogen, and methane remained unburnt, considerable amounts of uncombined oxygen were present. This is due to the fact that inadequate means are provided for the combustion of the "blow" gas, the burning mixture with air being cooled below reaction temperature by entering the tubes of the boilers before combustion has been completed. In Tests 2 and 3, although the maximum amount of air possible with the present arrangement was admitted to the top of each superheater, the amount was insufficient to have enabled complete oxidation even with more satisfactory combustion chambers. It is to be remembered that, although in one sense the carburettor and superheater may be regarded as combustion chambers for the waste-heat boilers, their performance in this respect is limited by the necessity for working these portions of the plant at temperatures suitable for the efficient cracking of oil. Determinations of the sulphur dioxide contained in the waste gases gave an average figure equivalent to 64 grains of sulphur per 100 c.ft.

Pressures, &c., on plant (Table III.).—The averages of the pressures at different positions in the plant recorded during the tests appear in Table III. The individual pressures taken during the "run" periods at the points before the wash-boxes gradually decreased from the beginning to the end of each "run" owing to a reduction in the rate of production of water gas resulting from the falling temperatures of the fuel in the generators and consequent lower percentages of steam decomposed. The average pressures in the air duct do not necessarily bear a simple relation to the rates of air flow, since these pressures are dependent not only on the resistance thrown by the fuel in the generators and by the carburettors, superheaters, and waste heat boilers, but also on the speed and efficiency of the blower. Two turbo-blower sets were available, but one only was in operation during each test. For purposes of reference one is designated A set and the other B. Although both sets A and B are of the same size and pattern, it is clear from the figures in Table III. for the speeds of the blowers in revolutions per minute and the pressures taken during the "run" periods in the air duct at the outlet of the blowers that the fan of set B was more efficient in operation than the fan of set A. This point was definitely proved by running both blowers at a speed of 1450 revs. per minute and noting the pressures at the outlets when the air valves were closed. It was found that set A gave a pressure of 18·75 ins. water gauge, as against about 25 ins. on set B. No attempt has therefore been made to calculate from the B.H.P. developed by the turbines even approximate volumes of air delivered, since it is clear that the mechanical efficiencies of the two blowers are widely different. The volumes of air supplied have been calculated from data obtained from carbon balances as described later in this report. The average pressures taken during the "blow" periods at the inlet to the condensers are higher than those at the inlets to the wash-boxes; this results from the operation of the seal in each of the two wash-boxes combined with the fact that gas-making was proceeding on one carburetted water gas set during the "blow" periods of the other and the condensers are common to both sets.

The average rates of flow of steam in the up "runs" and down "runs" on each machine during each test have been calculated from the pressures of steam at the nozzles of the steam meters and the respective throat areas, by means of the formula given in Appendix II. The steam was assumed to possess a dryness fraction x of 0·95, and the dis-

TABLE III.—*Pressures, &c., on Plant.*

Test No.	1.				2.				3.			
	Blow.		Run.		Blow.		Run.		Blow.		Run.	
Pressures in inches of water—												
Air duct, outlet blower	15·5		18·5		15·0		18·25		15·5		18·75	
Generator base	13·0		12·0		13·25		12·0		13·25		11·5	
Carburettor inlet	8·0		11·75		8·75		11·75		7·75		11·25	
Superheater inlet	5·5		11·25		6·5		11·5		6·25		11·0	
Wash-box inlet	2·0		10·25		3·0		10·25		2·75		10·0	
Condensers inlet	4·5		5·0		4·25		4·5		3·5		3·75	
Exhausters outlet	24				29				30			
Pressures in lbs. per square inch:—												
Oil pump outlet	106				103				90			
Waste heat boilers, steam	96				93				93			
Turbo-blower in operation—	A				B				A			
Speed of blower in revs. per minute	1400				1300				1450			
Steam pressure at nozzles of turbine, lbs. per sq. in.	54		39		45		19		57		37	
Machine in operation, No.—	3		4		3		4		3		4	
Direction of steam through generator	↑	↓	↑	↓	↑	↓	↑	↓	↑	↓	↑	↓
Diameter of nozzle of steam meter in ins.	1·006	1·000	1·000	1·000	1·006	1·000	1·000	1·000	1·006	1·000	1·000	1·000
Steam pressure at nozzles in lbs. per sq. in.	61·5	66·5	58·8	69·0	59·25	65·75	58·0	68 5	58·5	62·0	57·75	65·25
*Steam delivered in lbs. per minute (calculated from pressures)	52·2	54·9	49·8	56·5	50·7	54·5	49·4	56·3	50·2	52·0	49 2	54·1
Steam delivered in lbs. per minute as indicated by meter dials	50·6	52·9	49·7	53·5	49·0	52·5	49·75	53·25	48·5	50·25	49·25	51·0
Steam to generators in lbs. per 1000 c.ft. carburetted water gas—												
Calculated from item *	29·6				29·7				29·0			
Calculated from undecomposed steam and composition of water gas	29·5				29·8				29·0			

charge co-efficient of the nozzles was assumed to be 0·93, as in the calculations from the results of the tests carried out with the blue gas plant at Adderley Street (*vide* Sixth Report, Section III.). The results obtained are equivalent to overall average flows of steam for Tests 1, 2, and 3 of 51·7, 50·8, and 50·2 lbs. per minute respectively. Multiplying these figures by the total times occupied in steaming and dividing by the total volumes of carburetted gas made, it is found that the amounts of steam used per 1000 c.ft. of carburetted gas were 29·6 lbs., 29·7 lbs., and 29·0 lbs. respectively in the three tests. From experiments carried out for the determination of the concentrations of undecomposed steam in the carburetted water gas at the inlets to the wash-boxes and in the blue water gas leaving the generators it was found that the concentration of steam in the carburetted gas was approximately 84 p.ct. of that in the blue water gas made. Taking into account the fact that the temperatures of the carburettors and superheaters were probably too low to cause any appreciable quantity of steam leaving the generators to be decomposed during passage through the carburettors and superheaters, and that the oxygen content of the enriching oil was low, it seems reasonable to assume that the volume of blue water gas made was 84 p.ct. of the volume of carburetted gas, *i.e.*, that 1000 c.ft. of carburetted gas contained 840 c.ft. of blue water gas. By calculating the amounts of steam which must have been decomposed to produce 840 c.ft. of blue water gas of the compositions obtained in the tests and adding the determined quantities of undecomposed steam accompanying the blue gas, the resultant figures should represent the amounts of steam supplied to the generators per 1000 c.ft. of carburetted water gas made. The figures obtained by this method are shown in the last item of Table III. Comparing them with the figures in the previous item calculated from the pressures of steam on the nozzles and the throat areas, remarkable agreement is obtained. The figures are identical in Test 3, and differ by only 0·1 lb. of steam per 1000 c.ft. carburetted water gas in Tests 1 and 2. The agreement between the figures obtained by the two methods is so good that it might be considered a coincidence, for differences not greater than about 1 lb. would have been taken as very satisfactory. The figures not only confirm one another, but they also confirm the conclusion that the volume of blue water gas made in the test was about 84 p.ct. of the volume of carburetted gas.

Temperatures on plant (*Table IV.*).—The averages of the temperatures in degrees Centigrade during the tests at different positions in the plant appear in Table IV. The temperatures of the "blow" and "run" gases leaving the generators are much higher than those recorded in similar positions during the tests on the blue water gas plant which were described in the Sixth Report. These higher temperatures are due to the very different conditions of

TABLE IV.—*Temperatures on Plant.*

Test No.	1	2	3
Temperatures in degrees Centigrade—			
Blue water gas, outlet generator	638	638	638
Carburetted water gas, outlet carburettor	707	707	707
" " " superheater bottom	726	720	690
" " " " top	730	722	728
" " " inlet condensers	75	73	71
" " " outlet condensers	33	39	38
" " " rotary meter	8	9	10
Air, inlet generator	19·5	21·5	21·5
"Blow" gas, outlet generator	673	673	673
" " " carburettor	698	698	698
" " superheater bottom	707	717	687
" " " top	719	720	727
Waste gas, outlet waste heat boiler	320	310	307
Oil at inlet to carburettor	15·5	18	16

TABLE V.—*Analysis of Coke, Oil, Coke Recovered, Ashes, Clinker, and Tar* (*Dry Samples*).

Test No.	1.	2.	3.
Coke—Proximate analysis			
Volatile matter	3·1	3·1	2·7
Fixed carbon	84·8	85·7	86·9
Ash	12·1	11·2	10·4
	100·0	100·0	100·0
Ultimate analysis:			
Ash	12·1	11 2	10·4
Carbon	84·4	84·9	85·4
Hydrogen	0·7	0 7	0·7
Sulphur	1·3	1·2	1·2
Nitrogen and oxygen (difference)	1·5	2·0	2·3
	100·0	100·0	100·0
Calorific value (gross) in B.Th.U. per lb. (determined)	12,834	12,843	13,014
Oil—Ultimate analysis:			
Ash	0·0	0·0	0·0
Carbon	85·7	85·6	85·7
Hydrogen	12·7	12·7	12·7
Sulphur	0·5	0·5	0·4
Nitrogen and oxygen (difference)	1·1	1·2	1·2
	100 0	100·0	100·0
Specific gravity of oil at 15·5° C.	0·854	0·855	0·855
Calorific value (gross) in B.Th.U. per lb. (determined)	19,723	19,680	19,685
Coke recovered—Ultimate analysis:			
Ash	19·0		
Carbon	78·9		
Hydrogen	0·1		
Sulphur	0·9		
Nitrogen and oxygen (difference)	1·1		
	100·0		
Calorific value (gross) in B.Th.U. per lb. (determined)	11,700		
Ashes—Ultimate analysis:			
Ash	55·3	48·6	50·6
Carbon	43·6	50·5	48·7
Hydrogen	0·1	0·2	0·0
Sulphur	0·7	0·7	0·7
Nitrogen and oxygen (difference)	0·3	0·0	0·0
	100·0	100·0	100·0
Calorific value (gross) in B.Th.U. per lb. (calculated)	6,431	7,497	7,111

Test No.	1.	2.	3.
Clinker—Ultimate analysis:			
Ash	90·0	92·3	91·9
Carbon	9·6	7·0	7·7
Hydrogen	0 1	0·1	0·0
Sulphur	0·3	0 6	0·4
Nitrogen and oxygen (difference)	0·0	0·0	0·0
	100·0	100·0	100·0
Calorific value (gross) in B.Th.U. per lb. (calculated)	1,470	1,104	1,136
Tar recovered—Ultimate analysis (dry):			
Ash	0 4	0·3	0·3
Carbon	91·4	91·5	91·1
Hydrogen	6·2	6·2	6·2
Sulphur	1·2	1·1	1·1
Nitrogen and oxygen (difference)	0·8	0 9	1·3
	100·0	100·0	100·0
Specific gravity at 15·5° C.	1·098	1·095	1·096
Calorific value (gross) in B.Th.U. per lb. (determined)	17,138	17,247	17,211
Emulsion:			
Moisture per cent.	62·3	63·8	67·3
Ultimate analysis of dry tar in emulsion:			
Ash	1·4	1·4	1·5
Carbon	91·1	90·5	91·0
Hydrogen	6·2	6·0	6·1
Sulphur	1·3	1·2	1·2
Nitrogen and oxygen (difference)	0·0	0·9	0·2
	100·0	100·0	100·0
Specific gravity of tar at 15·5° C.	1·102	1·101	1·103
Calorific value (gross) in B.Th.U. per lb. (determined)	17,100	17,000	17,050

Tar and emulsion from	P. & A. Extractors.	Purifiers.
Moisture per cent.	45·0	58·5
Ultimate analysis of dry tar:		
Ash	0·4	0·5
Carbon	91·5	90·6
Hydrogen	6·1	6·3
Sulphur	0·9	1·8
Nitrogen and oxygen (difference)	1·1	0·8
	100·0	100·0
Specific gravity of dry tar at 15·5° C.	1·060	1·078
Calorific value (gross) in B.Th.U. per lb. (determined)	17,295	17,120

operation of the plant in the tests now under consideration. Investigations are being conducted by the Research Committee for the purpose of ascertaining to what extent the temperatures of the gases leaving a water gas generator are affected by changes in conditions of operation, and it is proposed to deal with this matter in a future report. The temperatures recorded at the outlets of the carburettors and in the superheaters during the "run" periods average only about 7° C. higher than those taken during the "blow" periods. This small average difference may have been due to the lag of the pyrometers and experimental error. The temperatures of the gases leaving the outlet waste-heat boilers averaged 312° C. for the three tests. These and other temperatures were measured as already described in this section under the heading "Measurements of Temperatures," and as described in Section II., to which attention is specially directed. The temperature 312° C. is higher than the figures previously given by other investigators for the gases leaving waste heat boilers of the same type working in conjunction with water gas plants; but it will be seen on reference to Section II. that the lower figures previously reported and published may well have resulted from errors due to the lag of the pyrometers used.

Ultimate analysis, calorific values, &c. (*Table V.*).—The results of proximate and ultimate analyses of the coke supplied to the generators, together with ultimate analyses of the enriching oil used, coke recovered, ashes and clinker withdrawn from the generators, and tar collected, are given in Table V. The analyses were all carried out on dried samples. The calorific values given for samples of coke, oil, coke recovered and tar were obtained by direct determinations in a Mahler-Kröcker bomb; but the calorific values of ashes and clinker have been calculated from the ultimate analyses by means of Dulong's formula (Appendix II.) since these substances could not be satisfactorily burned in the bomb. The specific gravities of the oil used and tar recovered are also included in the table.

Carbon Balances.

Carbon balances for the whole process have been drawn up from the results of analyses for the amounts of this element in the coke supplied to the generators, the oil supplied to the carburettors, the carburetted water gas made, the coke, ashes and clinker removed from the generators and the tar collected at different points of the plant. These balances are set out in Table VI. in which

TABLE VI.—*Carbon Balances of Production of Carburetted Water Gas in Lbs. per* 1000 *C.Ft. Gas Made.*

Test No.	1.	2.	3.
(*a*) Coke	29·97	30·69	30·16
(*b*) Oil	13·36	13·39	13·59
	43·33	44·08	43·75
1. Carburetted water gas	21·13	20·97	21·22
2. Coke recovered	1·18	..	..
3. Ashes	0·87	2·06	2·03
4. Clinker	0·17	0·09	0·09
5. Tar from separators	2·13	2·31	2·01
6. Emulsion from separators	0·26	0·26	0·20
7. Tar and emulsion from P. and A. extractors	0·24	0·25	0·25
8. Tar and emulsion from purifiers	0·11	0·12	0·11
9. Waste gas and carbon unaccounted for (difference)	17·24	18·02	17·84
	43·33	44·08	43·75

the figures given represent the weights of carbon in lbs. per 1000 c.ft. of carburetted water gas made. The difference item consists mainly of the carbon contained in the waste gases leaving the waste heat boilers, but it also includes any carbon lost by deposition in the carburettors and superheaters and carried away in other than gaseous form up the stack. In Table VII. the figures have been brought up in such proportions that the total amount of carbon supplied to the plant as coke to the generators and oil to the carburettors is represented as 100. The items in Table VII. therefore show the distribution of carbon in the products as percentages of the amounts supplied. It will be observed from a survey of the tables that approximately 48 p.ct. of the carbon appeared in the carburetted water gas, 40 p.ct. in the difference item

TABLE VII.—*Distribution of Carbon in Production of Carburetted Water Gas Per Cent.*

Test No.	1.	2.	3.
(*a*) Coke	69·17	69 62	68·94
(*b*) Oil	30·83	30·38	31·06
	100·00	100·00	100·00
1. Carburetted water gas	48·77	47·57	48·50
2. Coke recovered	2·72	..	..
3. Ashes	2·00	4·67	4·64
4. Clinker	0·39	0·20	0·21
5. Tar from separators	4·91	5·24	4·60
6. Emulsion from separators	0·60	0·59	0·46
7. Tar and emulsion from P. & A. extractors	0·56	0·57	0·57
8. Tar and emulsion from purifiers	0·25	0·27	0·25
9. Waste gas and carbon unaccounted for (difference)	39·80	40·89	40·77
	100·00	100·00	100·00

(waste gas and carbon unaccounted for), 6·3 p.ct. in the tar and the rest in the coke, ashes and clinker removed from the generators. By assuming that the whole of the carbon in the difference item, Table VI., is accounted for by the carbon carried away by the waste gas leaving the boilers, it is possible from the composition of the waste gas to calculate the volume produced per 1000 c.ft. of carburetted water gas made in each test. This method of calculation is not strictly accurate since it includes carbon lost; but it appears to be the only method of calculation available, and in any case the results obtained should be sufficiently accurate for the purpose of the tests. The volumes of waste gas produced per 1000 c.ft. of carburetted gas made, as calculated by this method, are 2573 c.ft., 2849 c.ft., and 2833 c.ft. respectively in the three tests.

Accepting the figures of 840 c.ft. already given as representing the volume of blue water gas required to produce 1000 c.ft. of the carburetted water gas made during the tests, the carbon balances given in Table VIII.

TABLE VIII.—*Carbon Balance of Generator Fuel in Lbs. per* 840 *C.Ft. Blue Water Gas.*

Test No.	1.	2.	3.
(*a*) Coke to generators	29·97	30·69	30·16
Accounted for as follows:			
1. Blue water gas	11·75	11 81	11·83
2. Coke recovered	1·18	..	..
3. Ashes	0·87	2·06	2·03
4. Clinker	0·17	0 09	0·09
5. Blow gas and carbon unaccounted for (difference)	16·00	16·73	16·21
	29·97	30 69	30·16

may be constructed. The figures given in these balances represent the lbs. of carbon in the coke supplied to the generators, the blue water gas made, and the coke, ashes, and clinker withdrawn from the generators per 840 c.ft. of blue water gas made. The difference item consists mainly of carbon carried away as blow gas, but it also includes solid carbon carried forward to the carburettors. In Table IX. the figures have been brought up in such

TABLE IX.—*Distribution of Carbon of Generator Fuel Per Cent.*

Test No.	1.	2.	3.
(*a*) Coke to generators	100·00	100·00	100·00
Accounted for as follows:			
1. Blue water gas	39·21	38·48	39·22
2. Coke recovered	3·94	..	..
3. Ashes	2·90	6·71	6·73
4. Clinker	0·57	0·29	0·30
5. Blow gas and carbon unaccounted for (difference)	53·38	54·52	53·75
	100·00	100·00	100·00

proportions that the amount of carbon in the coke supplied is represented as 100, so that the items show the distribution of carbon in the products as percentages of the carbon supplied. The figures show that approximately 39 p.ct. of the carbon of the coke was converted into blue water gas; the proportion converted into "blow" gas together with that carried forward in solid form was

approximately 54 p.ct., and the remainder was removed from the generators as coke, clinker, and ashes.

Assuming that the whole of the carbon in the difference item 5 of Table VIII. was converted into "blow" gas of the compositions given in Table II., the equivalent volumes of "blow" gas produced in Tests 1, 2, and 3 per 1000 c.ft. of carburetted gas would be respectively 1967 c.ft., 2057 c.ft., and 1985 c.ft., and the volume of air required to produce these amounts of "blow" gas would be 1774 c.ft., 1849 c.ft., and 1774 c.ft. Multiplying these last three figures by the corresponding total volumes of carburetted gas made during the tests and dividing by the times occupied by "blow" periods in minutes, it is found that the rates of supply of air to the generator were 6185 c.ft., 6306 c.ft., and 6129 c.ft. per minute of "blow."

The carbon balances of the enriching oil used in the tests and the products resulting from it are given in Table X., in lbs. per 1000 c.ft. of carburetted water gas made. The figures against item (1), carbon in oil gas, have been obtained by deducting the amounts of carbon in 840 c.ft. of blue water gas (Table VIII.) from the amounts in 1000 c.ft. of carburetted water gas (Table VI.). The difference item (6) includes any carbon deposited in the carburettors and superheaters and burned during the "burning-off" blows immediately preceding clinkering. The figures in Table X. have been converted to show the amounts

TABLE X.—*Carbon Balance of Oil to Carburettors in Lbs. per 1000 C.Ft. of Carburetted Water Gas.*

Test No.	1.	2.	3.
(*a*) Oil to carburettors	13·36	13·39	13·59
Accounted for as follows:—			
1. Carbon in oil gas	9·38	9·16	9 39
2. Tar from separators	2·13	2 31	2·01
3. Emulsion from separators	0 26	0 26	0 20
4. Tar and emulsion from P. and A. extractors	0·24	0·25	0·25
5. Tar and emulsion from purifiers	0·11	0·12	0·11
6. Carbon in waste gas and unaccounted for (difference)	1·24	1 29	1·63
	13 36	13·39	13·59

of carbon in the products as percentages of the carbon in the oil used. The results of these conversions appear in Table XI., from which it may be seen that of the carbon

TABLE XI.—*Distribution of Carbon of Oil to Carburettors Per Cent.*

Test No.	1.	2.	3.
(*a*) Oil to carburettors—	100·00	100·00	100·00
Accounted for as follows:			
1. Oil gas	70·21	68·41	69 09
2. Tar from separators	15·94	17·25	14 79
3. Emulsion from separators	1·95	1·94	1·47
4. Tar and emulsion from P. and A. extractors	1·80	1·87	1·84
5. Tar and emulsion from purifiers	0·82	0·90	0·81
6. Carbon in waste gas and unaccounted for (difference)	9·28	9·63	12·00
	100·00	100·00	100·00

in the oil approximately 69 p.ct. was gasified, 21 p.ct. was obtained in the tar collected, and the remaining 10 p.ct. was converted into waste gas or was lost in other ways.

AIR SUPPLIED TO GENERATORS, CARBURETTORS, AND SUPERHEATERS.

It has already been calculated that the amounts of waste gas produced during the tests were respectively 2573 c.ft., 2849 c.ft., and 2833 c.ft. per 1000 c.ft. of carburetted gas made. It can readily be calculated from the compositions in Table II. that these volumes must have required 2485 c.ft., 2813 c.ft., and 2771 c.ft. of air for their production. By deducting from these last figures the volumes of air supplied to the generators, the volumes supplied to the carburettors and superheaters may be obtained. For convenience the whole of the figures relating to the volumes of gases produced and air supplied per 1000 c.ft. of carburetted water gas made are grouped together in Table XII.: the average amounts of steam supplied to the generators in lbs. per minute during "run" periods and in lbs. per 1000 c.ft. carburetted water gas

TABLE XII.—*Volumes of Air Supplied and Gases Produced in Cubic Feet per 1000 C.Ft. Carburetted Water Gas Made, and Rates of Supply and Production in Cubic Feet per Minute.*

Test No.	1.	2.	3.
Volumes in cubic feet per 1000 c.ft. carburetted water gas—			
(*a*) Blue water gas produced	840	840	840
(*b*) Total air supplied to plant	2485	2813	2771
(*c*) Air to generators	1774	1849	1774
(*d*) Air to carburettors and superheaters	711	964	997
(*e*) "Blow" gas produced	1967	2057	1985
(*f*) Waste gas produced	2573	2848	2833
Rates in cubic feet per minute (average)—			
(1) Carburetted water gas during "run" periods	1744	1709	1729
(2) Blue water gas during "run" periods	1465	1436	1452
(3) Air to generators during "blow" periods	6185	6306	6129
(4) Air to carburettors and superheaters during "blow" and "burning-off" periods	2404	3530	3353
(5) "Blow" gas produced during "blow" periods	6857	7016	6858
(6) Waste gas produced during "blow" and "burning-off" periods	8700	9451	9529
Flow of steam—			
(*g*) Amount in lbs. per 1000 c.ft. carburetted water gas	29·5	29·8	29·0
(7) Rate in lbs. per minute of "run" periods	51·4	50·9	50·1

made are also included. From the figures given in the table it will be observed that in Test 1, the volume of air supplied to the carburettors and superheaters was 711 c.ft. per 1000 c.ft. C.W.G., as against nearly 1000 c.ft. of air during Tests 2 and 3; the difference of about 270 c.ft. representing the extra volume of air supplied to the top of the superheaters during Tests 2 and 3. The effect of this greater volume is also to be seen in the figures for volume of waste gas produced, items (*f*) and (6), and the *rate* of flow of air to carburettors and superheaters, item (4). The figures against the other items of the table are approximately the same in all three tests.

STEAM RAISED IN WASTE HEAT BOILERS.

The detailed figures relating to the performance of the waste heat boilers in the three tests appear in Table XIII.,

TABLE XIII.—*Steam Raised in Waste Heat Boilers.*

Test No.	1.	2.	3.
Water supplied to boiler, total in lbs.	873,360	993,100	553,670
Temperature of water supplied, degrees C.	21·1	20 0	18·3
Pressure of steam in boilers, lbs. per sq. in.	96	93	93
Water "blown-off" from boilers, total in lbs.	24,550	19,790	9,767
Temperature of water "blown-off" from boilers, degrees Centigrade	168·6	167·5	167·5
Water evaporated, total in lbs.	848,810	973,310	543,903
Water evaporated in lbs. per 1000 c.ft. carburetted water gas made	60·55	69·88	61·11
Heat in B.Th.U. required for evaporation per 1000 c.ft. carburetted water gas	66,986	77,412	67,875
Equivalent evaporation in lbs. from and at 100° C. per 1000 c.ft. carburetted water gas	69·01	79 75	69·92
Equivalent evaporation in lbs. from and at 100° C. per lb. of dry coke to generators	1·94	2·21	1·98
Water "blown-off" from boilers, lbs. per 1000 c.ft. carburetted water gas	1·75	1·42	1·10

which shows that the amounts of water actually evaporated per 1000 c.ft. of carburetted water gas made were 60·55 lbs., 69·88 lbs., and 61·11 lbs. respectively. These amounts were obtained when the boilers were supplied with cold water at an average temperature of about 20° C. It may be calculated that if the boilers had been supplied as in ordinary practice with water which had previously been heated to about 60° C. by passage through the condensers, the amounts of water evaporated could have been increased by approximately 3·5 lbs. per 1000 c.ft. C.W.G. made. The quantities of heat in B.Th.U. required for raising the amounts of steam obtained per 1000 c.ft. C.W.G. have been calculated on the assumption that the steam raised possessed a dryness fraction of 0·95. The average amount of steam raised per lb. of generator fuel is equivalent to about 2 lbs. from and at 100° C.

WATER BALANCES.

Water balances showing the amounts of steam raised in the waste-heat boilers and used in the various operations of the plant are given in Table XIV. The quantities of steam supplied to the turbine driving the blowers have been calculated from data provided by the makers (Messrs.

TABLE XIV.—*Water Balances. Steam in Lbs. per 1000 C.Ft. Carburetted Water Gas.*

Test No.	1.	2.	3.
Water evaporated in waste heat boilers	60·5	69·9	61·1
Accounted for as follows:			
Steam to generators	29·5	29·8	29·0
Steam to turbo-blower	12·1	10·0	12·5
Steam to exhausters, oil pump, and boiler feed pump	18·9	18·9	18·9
Steam available for other purposes	0·0	11·2	0·7
	60·5	69·9	61·1
Water equivalent of 840 c.ft. blue water gas	20·4	20·9	20·7
Water vapour accompanying 840 c.ft. blue water gas	9·1	8·9	8·3
Total steam to generators per 840 c.ft. blue water gas	29·5	29·8	29·0
Steam to generators decomposed, p.ct.	69	70	71

Greenwood and Batley) regarding the steam consumption with different pressures of steam on the nozzles. Since the steam raised in the first test was just sufficient to supply the generators, drive the blower, exhausters, oil pump, and boiler feed pump, the amount required for the auxiliary plant is obtained by deducting the amount supplied to the generators and turbine from the total. The figure thus obtained (18·9 lbs.) to represent the steam consumption of the auxiliary plant has been assumed to be the same for all three tests. In this manner it has been possible to construct balances for Tests 2 and 3 for the purpose of ascertaining the extra amount of steam raised by the waste-heat boilers and available for use on other plant. The amounts of steam decomposed in the generators per 1000 c.ft. of C.W.G. are represented by the amounts equivalent to 840 c.ft. of blue water gas. These amounts average 70 p.ct. of the steam supplied to the generators. The value 70 p.ct. is within 1 p.ct. of the percentage decomposition of steam in the generator of the blue gas plant at Adderley Street, Birmingham, during the tests described in the Sixth Report.

HEAT BALANCES AND THERMAL EFFICIENCIES OF GAS PRODUCTION.

The heat balances of the whole process of production of carburetted water gas as carried out in the tests are set out in Table XV., in which the different items are given in therms per 1000 c.ft. of carburetted water gas made. Three sources of heat in the complete process are considered:—

(*a*) Heat supplied as fuel to the generators.
(*b*) Heat supplied as oil to the carburettors, and
(*c*) Sensible heat of air supplied by the blower.

The expenditure of the total heat in the three items is accounted for in fourteen items:

(1) Potential heat of carburetted water gas calculated from the gross calorific values in Table I.
(2) Sensible heat of carburetted water gas at outlets of superheaters.
(3) Total heat of undecomposed steam at oulet of superheaters.
(4) Potential heat of the whole of the tar collected.
(5) Sensible heat of tar at outlets of superheaters.
(6) Potential heat of waste gas calculated from the volumes given in Table XII. and the gross calorific values given in Table II.
(7) Sensible heat of waste gas at the outlets of the waste-heat boilers. This item includes the total heat of water vapour accompanying the waste gas.
(8) Total heat of steam raised in waste-heat boilers. The figures in this item represent the total heat values of the steam raised in excess of that required to supply the generators; the total heat value of the steam supplied to the generators is not included since in such case it would be necessary to include it also in the heat supplied.
(9) Heat required to raise the temperature of the water "blown-off" from the boilers from the temperature at which it entered the boilers to that at which it left.
(10) (11) and (12) Potential heats of coke recovered, ashes and clinker calculated from the amounts in Table I. and the calorific values in Table V.
(13) Sensible heat of the coke recovered, ashes and clinker on the assumption that they were withdrawn from the generators at 800° C., and
(14) The balance which includes losses not separately determined.

The values of the heat capacities used in the calculations of the various items are given in Appendix II. It should be noted that throughout the balances in Table XV. the calorific values were taken at ordinary temperature (15·5° C.), and that the figures for amount of sensible heat represent the differences of the heat contents at ordinary temperature and at the temperature of the substance under consideration.

TABLE XV.—*Heat Balances in Production of Carburetted Water Gas in Therms per 1000 C.Ft. Gas Made.*

Test No.	1.	2.	3.
Heat supplied—			
(*a*) Coke to generators, heat of combustion	4·557	4·643	4·597
(*b*) Oil to carburettors, heat of combustion	3·074	3·081	3·122
(*c*) Sensible heat of air to blower	0·003	0·005	0·005
	7·634	7·729	7·724
Accounted for as follows—			
1. Carburetted water gas, potential heat	4·840	4·810	4·850
2. " " " sensible heat	0·320	0·315	0·319
3. Steam not decomposed, total heat	0·162	0·158	0·148
4. Tar, potential heat	0·514	0·555	0·487
5. Tar, sensible heat	0·022	0·024	0·021
6. Waste gas, potential heat	0·576	0·422	0·518
7. Waste gas, sensible heat	0·316	0·331	0·333
8. Heat to raise steam in waste heat boilers	0·343	0·444	0·357
9. Heat supplied to water "blown off" from boilers	0·005	0·004	0·003
10. Coke recovered, potential heat	0·174	..	..
11. Ashes, potential heat	0·128	0·306	0·296
12. Clinker, potential heat	0·026	0·015	0·013
13. Coke recovered, ashes, and clinker, sensible heat	0·016	0·016	0·016
14. Losses not separately determined, leakages, radiation, convection, &c. (difference)	0·192	0·329	0·363
	7·634	7·729	7·724

In the heat balances in Table XVI. the value of the total amount of heat supplied is taken as 100 and the other figures are in proportion, so that the items appear as percentages of the total heat supplied to the generators and carburettors. The thermal efficiencies of gas production are also included in the table. These figures, which average approximately 68 p.ct., have been calculated according to the principle defined in the Clerk-Smithells-Cobb report to the Institution in 1919, *i.e.*, the thermal efficiency is given by the heat in the gas multiplied by 100 and divided by the sum of the heat in the gas and heat used and lost in manufacture. Following this definition, the thermal efficiencies of gas production are given by item (1) multiplied by 100 and divided by the figure obtained by

TABLE XVI.—*Heat Balances in Production of Carburetted Water Gas Per Cent.*

Test No.	1.	2.	3.
Heat supplied—			
(*a*) Coke to generators, heat of combustion	59·70	60·07	59·52
(*b*) Oil to carburettors, heat of combustion	40·26	39·87	40·42
(*c*) Sensible heat of air to blower	0·04	0·06	0·06
	100·00	100·00	100·00
Accounted for as follows—			
1. Carburetted water gas, potential heat	63·40	62·23	62·79
2. " " " sensible heat	4·19	4·08	4·13
3. Steam not decomposed, total heat	2·12	2·04	1·92
4. Tar, potential heat	6·73	7·18	6·31
5. Tar, sensible heat	0·29	0·31	0·27
6. Waste gas, potential heat	7·55	5·46	6·71
7. Waste gas, sensible heat	4·14	4·28	4·31
8. Heat to raise steam in waste heat boilers	4·49	5·75	4·62
9. Heat supplied to water "blown off" from boilers	0·07	0·05	0·04
10. Coke recovered, potential heat	2·28	..	..
11. Ashes, potential heat	1·68	3·96	3·83
12. Clinker, potential heat	0·34	0·19	0·17
13. Coke recovered, ashes and clinker, sensible heat	0·21	0·21	0·21
14. Losses not separately determined, leakages, radiation, convection, &c. (difference)	2·51	4·26	4·69
	100·00	100·00	100·00
Efficiency of gas production per cent.	68·0	68·2	67·1

deducting the heat value of the steam raised in excess of that required for driving the blower and auxiliary plant from the sum of items (1), (2), (3), (5), (6), (7), (8), (9), (10), (11), (12), (13), and (14). This simplifies to the expression :—

$$\frac{\text{item (1)} \times 100}{100 - (\text{item (4)} + \text{extra steam})}$$

tar and extra steam being the only useful products apart from the gas made.

It will be noted that in Test 1 the heat in item (10), coke recovered, has been considered as lost; which would have been the case in ordinary practice. If the process is credited with the coke recovered, then the efficiency given for Test 1 would be increased from 68 p.ct. to 69·7 p.ct. If the steam required for the generators, blowers, and auxiliary plant had been raised externally in boilers with 70 p.ct. efficiency, the efficiencies of gas production in the tests would have been 59·9 p.ct., 59·4 p.ct., and 59·2 p.ct. respectively, or approximately 8·5 p.ct. less than when the steam is raised in waste-heat boilers.

The balances in Table XVI. indicate where the heat losses occurred, and consequently where possible economies might be effected. The greatest individual loss is represented by the potential heat of the waste gas, which accounts for approximately 6·7 p.ct. of the total heat supplied. This loss might be reduced by improvement in the method of combustion of the gas leaving the superheaters before it enters the waste-heat boilers.

The heat balances of the generator alone are set out in Table XVII., in which the different items are given in

TABLE XVII.—*Heat Balances of Generators in Therms per 840 C.Ft. Blue Water Gas Made.*

Test No.	1.	2.	3.
Heat supplied—			
(*a*) Coke to generators, heat of combustion	4·557	4·643	4·597
(*b*) Total heat of steam to generators	0·327	0·330	0·322
(*c*) Sensible heat of air to generators	0·003	0·004	0·004
	4·887	4·977	4·923
Accounted for as follows—			
1. Blue water gas, potential heat	2·436	2·461	2·470
2. ,, ,, ,, sensible heat	0·180	0·181	0·180
3. Steam not decomposed, total heat	0·153	0·149	0·139
4. Blow gas, potential heat	1·092	1·148	1·108
5. ,, ,, sensible heat	0·491	0·503	0·498
6. Coke recovered, potential heat	0·174	..	..
7. Ashes, potential heat	0·128	0·306	0·296
8. Clinker, potential heat	0·026	0·015	0·013
9. Coke recovered, ashes and clinker, sensible heat	0·016	0·016	0·016
10. Losses not separately determined, leakages, radiation, convection, &c. (difference)	0·191	0·198	0·203
	4·887	4·977	4·923

therms per 840 c.ft. of blue water gas, which was the amount required for the production of 1000 c.ft. of carburetted gas made in the tests. In the balances in Table XVIII. the value of the total heat supplied is taken as 100, and the other items are in proportion, so that the figures

TABLE XVIII.—*Heat Balances of Generators Per Cent.*

Test No.	1.	2.	3.
Heat supplied—			
(*a*) Coke to generators, heat of combustion	93·25	93·29	93·38
(*b*) Total heat of steam to generators	6·69	6·63	6·54
(*c*) Sensible heat of air to generators	0·06	0·08	0·08
	100·00	100·00	100·00
Accounted for as follows—			
1. Blue water gas, potential heat	49·85	49·45	50·17
2. ,, ,, ,, sensible heat	3·68	3·64	3·66
3. Steam not decomposed, total heat	3·13	2·99	2·82
4. Blow gas, potential heat	22·34	23·07	22·51
5. ,, ,, sensible heat	10·05	10·11	10·12
6. Coke recovered, potential heat	3·56	..	..
7. Ashes, potential heat	2·62	6·15	6·01
8. Clinker, potential heat	0·53	0·30	0·26
9. Coke recovered, ashes and clinker, sensible heat	0·33	0·32	0·33
10. Losses not separately determined, leakages, radiation, convection, &c. (difference)	3·91	3·97	4·12
	100·00	100·00	100·00
Thermal efficiency of production of blue water gas, per cent.—heat values of steam raised and required *not* taken into account	53·4*	53·0	53·7

* No allowance has been made in this figure for the potential heat value of the coke recovered, item (6). If this potential heat were regarded as wholly available, the efficiency figure would be raised from 53·4 p.ct. to 55·5 p.ct.

appear as percentages of the heat to the generators. The thermal efficiencies of gas production without taking into account the steam raised in the waste-heat boilers and required for the plant average 53·4 p.ct. The corresponding figure obtained in the tests of the blue gas plant at Adderley Street (Sixth Report) was 56 p.ct. With regard to the effect of moisture in the coke as charged, it seems likely that, when working with a deep fuel bed, the moisture is driven off by the gases produced in the lower part of the fuel bed before the coke reaches the zone of gasification. In such case variations in the moisture content of the coke, within ordinary limits, would have little effect on the thermal efficiency of production of blue gas.

The heat balances of the waste-heat boilers alone appear in Table XIX., in which the different items are given in

TABLE XIX.—*Heat Balances of Waste Heat Boilers in Therms per 1000 C.Ft. Carburetted Water Gas Made.*

Test No.	1.	2.	3.
1. Total heat of steam raised	0·670	0·774	0·679
2. Heat supplied to water "blown off" from boilers	0·005	0·004	0·003
3. Waste gas, potential heat	0·576	0·422	0·518
4. Waste gas, sensible heat	0·316	0·331	0·333
5. Losses, radiation, convection, &c. (assumed)	0·032	0·031	0·031
6. Total heat entering boiler	1·599	1 562	1·564
Thermal efficiency of boiler per cent. $\frac{\text{item (1)} \times 100}{\text{item (6)}}$	41·9	49·6	43·4

therms per 1000 c.ft. of carburetted water gas made. The balances are made up of six items—(1) total heat of steam raised, (2) heat carried away by water "blown-off" from boilers, (3) potential heat of waste gases leaving the boilers, (4) sensible heat of waste gases leaving the boilers, (5) losses due to radiation, convection, &c.; these losses have been assumed to be 2 p.ct. of the total heat entering the boilers, and (6) the total of the previous items. As already pointed out under the heading "Sampling" in this section of the report, the samples of gas taken from the inlet gas chambers of the waste-heat boilers were not satisfactory, since they changed in composition during passage through the sampling tubes, not merely as a result of further reaction between the burning gases themselves, but also by interaction with particles of hot carbon. It has, therefore, been necessary to take the figures against item (6) as representing the heat entering the boilers. The thermal efficiencies of the boilers which show the heat in the steam raised as percentages of the total heat entering were 41·9 p.ct., 49·6 p.ct., and 43·4 p.ct. respectively for the three tests.

The heat values in therms of the enriching oil used and the products obtained from it per 1000 c.ft. of carburetted water gas made are shown in Table XX.; and the heat values of the products appear in Table XXI. as percentages of the heat value of the oil used. From the figures in

TABLE XX.—*Heat Values of Oil and Products in Therms per 1000 C.Ft. Carburetted Water Gas Made.*

Test No.	1.	2.	3.
Oil to carburettors, heat of combustion	3·074	3·081	3·122
Products—			
1. Oil gas	2·404	2·349	2·380
2. Tar	0·399	0·436	0·381
3. Emulsion	0·049	0·049	0·038
4. Tar and emulsion from P. and A. extractors	0·046	0·048	0·048
5. Tar and emulsion drained from purifier boxes and pipes	0·020	0·022	0·020
	2·918	2·904	2·867

TABLE XXI.—*Heat Values of Products of Oil Expressed as Percentages of the Heat Value of Oil.*

Test No.	1.	2.	3.
Oil to carburettors, heat of combustion	100·0	100·0	100·0
Products—			
1. Oil gas	78·2	76·2	76·2
2. Tar	13·0	14·2	12·2
3. Emulsion	1·6	1·6	1·2
4. Tar and emulsion from P. and A. extractors	1·5	1·6	1·5
5. Tar and emulsion drained from purifier boxes and pipes	0·6	0·7	0·7
	94·9	94·3	91·8

Table XXI. it may be seen that of the heat value of the oil approximately 77 p.ct. appears in the carburetted gas and

TABLE XXII.—*Results per* 1000 *C.Ft. Carburetted Water Gas Made.*

Test No.	1.	2.	3.
Coke (dry) in lbs. to generators	35·51	36·15	35·32
Carbon in coke in lbs. to generators	29·97	30·69	30·16
Oil in gallons to carburettors	1·826	1·830	1·854
Carbon in oil in lbs. to carburettors	13·36	13·39	13·59
Thermal value of carburetted water gas in therms (gross)	4·84	4·81	4·85
Volume of blue water gas, cubic feet	840	840	840
Total tar (dry) collected, in gallons	0·274	0·295	0·259
Steam to generators in lbs.	29·5	29·8	29·0
,, turbo-blower in lbs.	12·1	10·0	12·5
,, exhausters, oil pump, and boiler feed pump in lbs.	18·9	18·9	18·9
Total steam required in lbs.	60·5	58·7	60·4
Steam raised in waste-heat boilers in lbs.	60·5	69·9	61·1
Equivalent evaporation in lbs. from and at 100° C.	69·0	79·8	69·9
Over-all thermal efficiency of gas production per cent.	68·0	68·2	67·1

about 16 p.ct. in the tar collected, leaving 7 p.ct. unaccounted for. Utilizing the figures given in the thermal balances in Tables XV. to XXI., and so taking into account the heat supplied in the carburettors and superheaters for the decomposition of the oil, it may be calculated that the approximate efficiency of oil gas production was 90 p.ct.

For convenience in reference, a number of the results obtained per 1000 c.ft. of carburetted gas made in the tests are grouped together in Table XXII.

DEPOSITION OF DUST IN PLANT.

In the Sixth Report of the Gas Investigation Committee reference was made to the trouble caused by the deposition of a yellow-brown powder in a finely divided condition in almost all sections of the plant beyond the scrubber. The deposit was found even beyond the relief holder and on the vanes of the rotary meter used for measuring the crude gas. It consisted mainly of free silica and also contained free sulphur. During the tests on the carburetted water gas plant at Windsor Street no trouble has been caused by any similar deposit, although it was clear from experiments carried out at the outlet generators that a similar dust was carried forward to the carburettors by the blue water gas made. The dust must therefore have been removed from the gas during passage through the carburettors and superheaters or carried away by the tar which condensed out afterwards.

DISTILLATION TESTS OF OIL AND TAR.

Samples of the oil used in the three tests were examined by distillation in a standard Engler flask. 100 c.c. of the oil were used for each distillation and the total amounts collected at each 10° C. rise in the temperature, as indicated by means of a thermometer placed just below the side tube of the flask, were measured. The distillations were carried out at the rate of 7 c.c. per minute, and the following results were obtained :—

Distillation Tests of Oils.

Test No.	1.	2.	3.
Volume in c.c. taken for distillation	100·0	100·0	100 0
Temperature of first drop in degrees C.	210	208	205
Fraction in c.c. over range of 10° C.—			
200–210	—	0·2	0·2
210–220	1·3	2·6	2·3
220–230	4·8	4·1	4·5
230–240	6·2	7·5	5·5
240–250	8·0	9·8	9·5
250–260	9·3	8·0	9·5
260–270	8·9	8·1	8·9
270–280	7·6	8·7	7 5
280–290	8·5	8·1	7·8
290–300	6·5	7·5	8·1
300–310	5 8	5·7	4·6
310–320	5·9	5·2	6·2
320–330	4·4	4·6	4·9
330–340	4·3	3·0	3·4
340–350	3 4	3·6	3·4
*Over 350 (difference)	15 1	13·3	13·7
	100·0	100·0	100 0
Flash point degrees C.	82·5	80·0	80·0
Viscosity at 60° Fahr. (rape oil = 100)	7·15	7·0	7·0

* The residue in the flask was a viscous oil and not a pitch.

The flash points of the oils determined by means of Gray's apparatus were 82·5° C. for the oil used in Test 1, 80·0° C. for Test 2, and 80·0° C. for Test 3. The viscosities measured in Redwood's viscometer were found to be 7·15, 7·0, and 7·0 respectively compared with a standard rape oil taken as 100 at 60° Fahr.

For the purpose of carrying out a distillation test on the tar recovered, a composite sample of tar was made up by mixing together amounts of dehydrated tar obtained during the tests in proportion to the quantity recovered in each test. The distillation experiment was then made on 500 c.c. of the composite sample contained in a 1000 c.c. distilling flask ; and the following results were obtained :—

Distillation Test of Dehydrated Tar.

First drop	83° C.
Fractions as per cent volume of dry tar—	
Below 170° C.	3·65
170–230° C.	12·35
230–270° C.	26·90
270–350° C.	27·80
Pitch (by difference)	29·30
	100·00
Twist point of pitch	54° C.
Melting ,, ,,	80° C.
Quality of pitch	Medium

Examination of the fractions obtained on distillation of the dry tar led to the conclusion that it was rich in naphthalene.

Determinations of the "free carbon" in the tar and emulsion collected during the tests were also made. The method of determination adopted was the same as that described in the Fourth Report. The following results were obtained :—

"Free Carbon" in Tar.

Test No.	1.	2.	3.
"Free carbon" as per cent. of dry tar—			
Tar recovered	0·69	0·55	0·62
Tar in emulsion	2·54	2·09	2·45

From these results it will be observed that the tar in the emulsion contained much more "free carbon" than the tar recovered; the ash contents were also higher (Table V.).

SECTION II.

MEASUREMENTS OF TEMPERATURES.

As previously mentioned in Section I., in addition to the pyrometer readings taken during complete tests, special investigations were conducted for the purpose of determining the temperatures of the gases leaving the generators, carburettors, superheaters and waste heat boilers. Prior to the commencement of the complete tests, seven iron-sheathed thermo-couples of iron-constantan wires of 5/16 in. diameter were installed in each plant at the following points : (1) top outlet of generator, (2) bottom outlet of generator, (3) outlet of carburettor, (4) bottom of superheater, (5) top of superheater, (6) inlet gas chamber of waste heat boiler, and (7) outlet gas chamber of waste heat boiler. The thermo-couples and indicators were carefully calibrated before installation ; and the indicators, which were placed in the coolest position on the operating platform, were connected to the couples by iron-constantan leads. Corrections were applied to all readings to allow for the cold junction temperature at the indicators. During the special investigations, the machines were operated as nearly as possible under the same conditions as those adopted during the complete tests. After trials extending over several weeks, it was found, however, on testing with a potential of 4 volts, that twelve of the fourteen thermo-couples had become earthed. The couples were therefore taken out and examined ; and it was proved that the earthing had been caused by (1) the formation of carbon by the decomposition of organic matter contained in the asbestos cord used for the purpose of insulating the thermo-couple leads or (2) the deposition of carbon as a result of the decomposition of hydrocarbon gases which had passed through the metal of the iron sheaths, or both (1) and (2). After a number of experiments, the asbestos cord was finally replaced either by short lengths of silica tube or by alundum. The alundum insulation was made by mixing the powder with water into a paste, which was moulded round the leads of the couples. The paste was then dried

first at ordinary temperatures and afterwards at higher temperatures for several days. Both methods of insulation proved satisfactory for the purpose of preventing the short-circuiting of the leads. Couples insulated by these methods were placed in iron sheaths and used for measuring the temperatures of the gases leaving the generators and waste heat boilers. The iron sheaths, which were porous to hydrocarbon gases, could not satisfactorily be used at the outlets of the carburettors or in the superheaters, at which points porcelain sheaths were therefore installed. The porcelain tubes have proved themselves satisfactory over several weeks, but longer trials are required to determine their value under ordinary works conditions.

During the special investigations, readings of the temperatures of the gases leaving the generators and carburettors and passing through the superheaters were taken every 12 seconds throughout complete clinker to clinker periods, in the manner illustrated by the following example.

Temperature Readings in Degrees Centigrade.

Time of		"Blow" 2 Minutes. Readings every 12 Secs.					Time of Run.	"Run" 4 Minutes. Readings every 12 Secs.				
Coking.	Blow.	Generator Outlet.		Carburettor Outlet.	Superheater.			Generator Outlet.		Carburettor Outlet.	Superheater.	
p.m.	p.m.	Top.	Bot.		Bot.	Top.	p.m.	Top.	Bot.		Bot.	Top.
2.28	2.47	682	360	649	688	721						
	2.48	693	355	665	705	716						
							2.49	710	360	693	721	721
							2.50	721	371	693	721	710
							2.51	716	371	682	716	716
							2.52	716	371	665	710	716

Two readings, therefore, were taken at each point during a "blow" period, four during a "run" period and one during the minute occupied in charging the generator. The average temperatures of the gases for the complete tests were computed from series of readings taken in this manner, combined with similar readings taken periodically during the tests. Since there were no rapid changes in temperature at these points, errors due to the lag of the pyrometers should be small.

The temperatures of the gases entering and leaving the waste heat boilers were read off every ten seconds; so that in each case there were twelve readings during a "blow" period and twenty-four readings during a "run" period. The temperatures at these points, however, changed so rapidly during each "blow" and each "run" period that the lag of the sheathed thermo-couples must have caused considerable errors in the results obtained. Series of measurements over long periods were therefore taken at these points with (1) the sheathed iron-constantan couples, (2) bare iron-constantan couples of metal 1/20 in. diameter, and (3) a thin platinum-platinum rhodium couple. The character of the results obtained is shown graphically in Diagrams V. and VI., in which each curve is constructed from a typical set of readings taken during a six-minutes cycle consisting of two-minutes "blow" and four-minutes "run." The curves in Diagram V. represent the temperature readings obtained with the thermo-couples placed in the inlet gas chamber of one of the waste heat boilers, and those in Diagram VI. are constructed from readings similarly obtained with the couples placed in the outlet gas chamber of the boiler. The curves in both diagrams clearly show the magnitude of the errors which may result from lag, when using thermo-couples of stout metal or enclosed in sheaths, for the purpose of registering rapidly-changing temperatures. The thin platinum couple responded to sudden changes much more rapidly than either of the iron-constantan couples; and the lag of the sheathed couple was so great that it did not reach a maximum temperature until one minute after the stack valve had been closed and the flow of gas through the boiler had ceased. It is quite evident from these curves that the averages of the temperatures of the gases entering and leaving the boilers during the "blow" periods, as deduced from readings of sheathed base metal thermo-couples similar to those ordinarily used in works practice, may be very much lower than the true averages. Sheathed pyrometers give comparative readings which are of value in controlling the plant for ordinary purposes of manufacture; and they could not, under such circumstances, be replaced by thermo-couples without sheaths, since these would soon be destroyed. When accurate readings are required, however, rapidly changing temperatures must be recorded by pyrometers directly exposed.

It is interesting to analyse the curve (Diagram V.) constructed from the readings taken every ten seconds with the platinum couple. At the commencement of the "blow" period, the valves are operated in the following order—(1) steam to generator shut-off, (2) blast valve opened, (3) stack valve closed, (4) air valve at top of superheater opened, and (5) air valve at top of carburettor opened. As soon as the blast valve to the generator and air valve at the top of the superheater have been opened, combustion of "blow" gas takes place with the production of flame in the top of the superheater and the inlet gas chamber of the boiler. This is shown by the sudden rise in temperature which commences at point A on the curve. The curve then rises rapidly at first and then more gradually until the commencement of the third minute. At this point the steam valve to the generator is opened and the other valves are

DIAGRAM V.—TEMPERATURES OF GAS ENTERING WASTE HEAT BOILER.

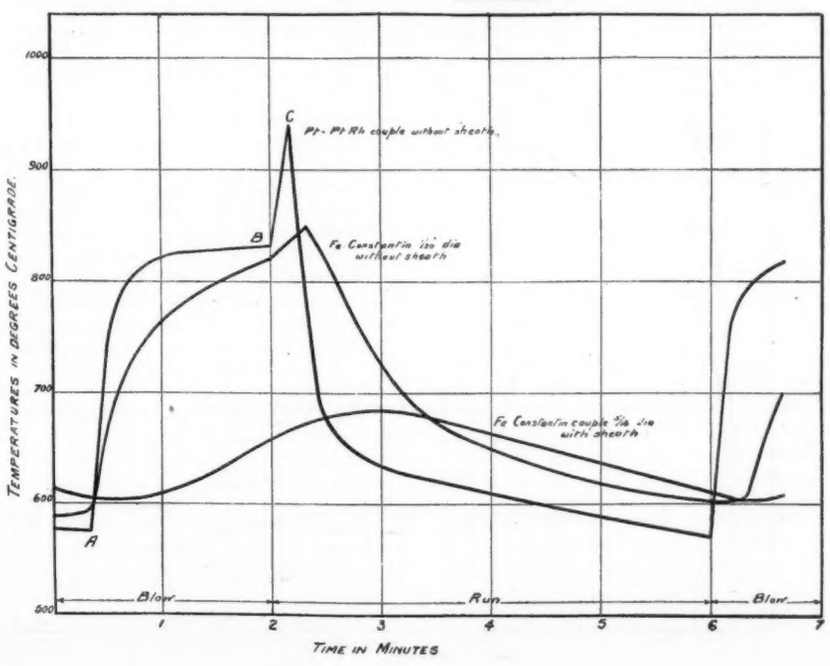
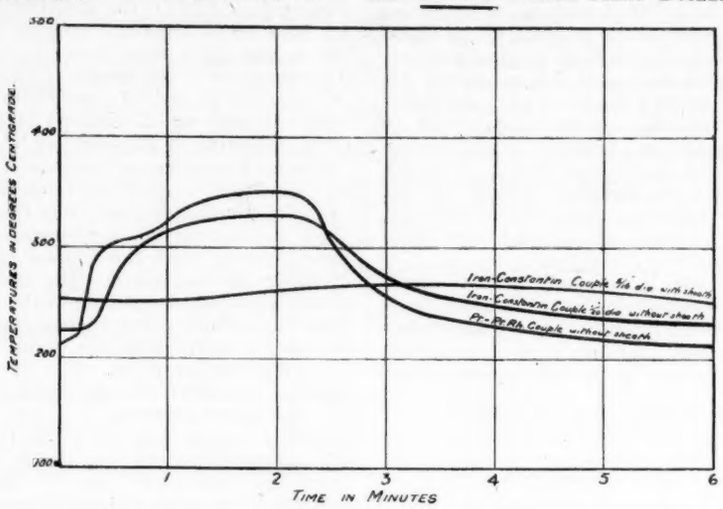


DIAGRAM VI.—TEMPERATURES OF GAS LEAVING WASTE HEAT BOILER.



operated in the following order—(1) blast valve to generator closed, (2) air valve at top of carburettor closed, (3) air valve at top of superheater closed, and (4) stack valve closed. It would appear that before the air valve at the top of the superheater is closed a small quantity of water gas finds its way to the top of the superheater, where together with "blow" gas it is mixed with a supply of air which increased as soon as the blast valve to the generator was closed. A relatively large amount of heat is therefore developed during the few seconds which elapse between the closing of the blast valve and the closing of the air valve at the top of the superheater, with the result that the curve shows another marked rise from B to C. As soon as the stack valve is closed, the waste heat boiler is out of circuit. The curve then falls, rapidly at first and afterwards more slowly during the "run" period. The characteristics of the curve obtained with the platinum couple appear in the curve from the results with the iron-constantan couple without sheath, but the changes in temperature are not brought out to the same extent owing to the greater lag of the latter couple. With the sheathed couple, the lag is so great that the sudden changes in temperature with the operation of the valves cannot be observed in the curve.

The curve (Diagram VI.) obtained with the platinum couple placed in the outlet gas chamber of the waste heat boiler, shows a marked rise as soon as the stack valve is opened, followed by a more gradual rise in temperature lasting until the stack valve is closed at the end of the "blow" period. During the "run" period the temperature falls according to the usual type of cooling curve. The same characteristics appear in the curve of the results obtained with the iron-constantan couple without sheath; but no rapid changes in temperature appear in the curve of the readings taken with the sheathed couple. It was found from several series of experiments that the average temperatures of the gases leaving the waste heat boilers as deduced from readings with the sheathed thermo-couples were more than 50° C. below the true averages.

The curves in Diagrams VII. and VIII. show the differences in the temperatures obtained in the inlet and outlet gas chambers of the waste heat boilers when different amounts of air are admitted to the top of the superheater. The temperatures were taken in these instances with the platinum couple, and the curves show the same characteristics as the curves with this couple in Diagrams V. and VI.

Temperatures of Superheater and Carburettor.—During the "blow" periods the air valve at the top of each carburettor was adjusted to admit sufficient air for burning the quantity of gas which would generate the heat required for maintaining the carburettor and superheater at the desired temperatures, as shown by the sheathed iron-constantan couples inserted in the superheater near the top and the bottom. The temperatures could also be judged, approximately, by means of glass-covered sight holes placed in the walls of the carburettor and superheater.

In addition, special "cracking" tests were carried out

DIAGRAM VII.—TEMPERATURES OF GAS ENTERING WASTE HEAT BOILER.

Pt.—Pt. Rh. couple (without sheath).

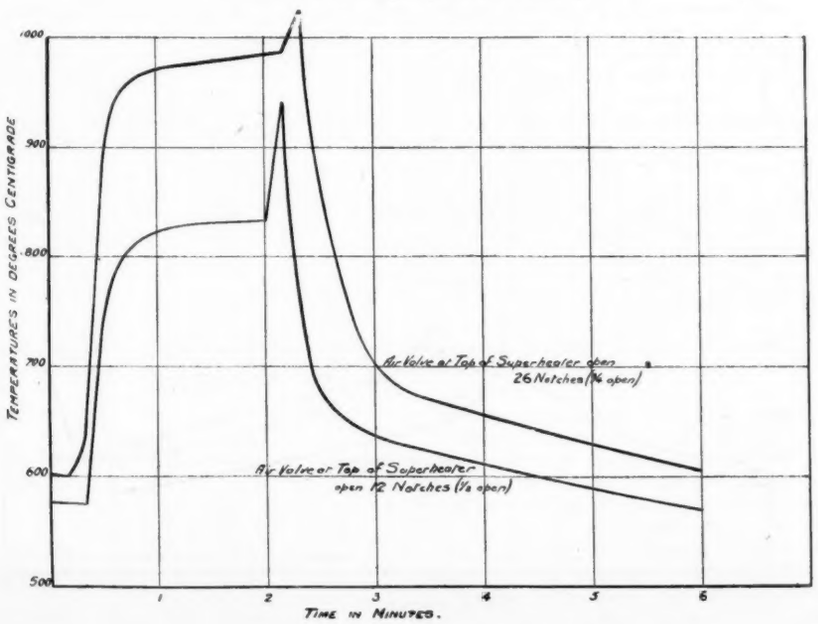
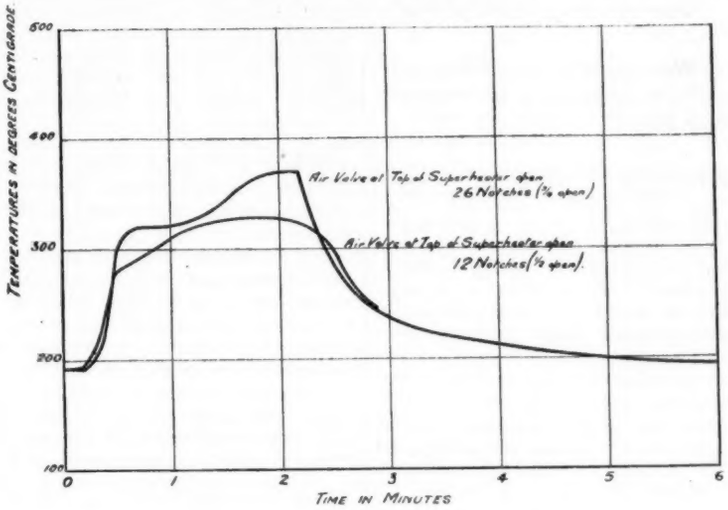


DIAGRAM VIII.—TEMPERATURES OF GAS LEAVING WASTE HEAT BOILER.

Pt.—Pt. Rh. couple (without sheath).



every half-hour on each machine, in the manner frequently adopted in ordinary practice. A stream of gas was allowed to emerge from an orifice of about ⅛ in. diameter controlled by a cock placed in the sight hole tube near the top of the superheater. This stream was projected on to a piece of white paper placed about 2 ins. in front of the orifice. The paper was exposed for ½ minute after a "run" period had been in progress for 1½ minutes, *i.e.*, during the time (3 minutes) of admission of oil to the carburettor. When the test is carried out in the manner described, a brown deposit is formed on the paper. After some experience, it is possible from the nature of the deposit to form an idea as to whether the oil is being cracked efficiently or not. With the best "cracking" temperatures the deposit is light brown in colour with very few particles of carbon. When the temperature is too low, the deposit includes a film of oil, and when too high a larger quantity of free carbon is obtained. The test papers were gummed in order in a book kept for the purpose and the times of testing were systematically recorded. This test, however, could only be used as a very rough guide.

THE COMPOSITIONS OF BLUE WATER GAS AND BLOW GAS AT THE DIFFERENT STAGES OF OPERATION OF THE PLANT.

This subject was dealt with in a comprehensive manner in October last year in Section II. of the Sixth Report of the Research Sub-Committee of the Institution. It was not considered necessary, therefore, to carry out an investigation so complete in detail with the plant at Windsor Street. It was believed, however, that a number of analyses of samples of the gases produced at different stages would be useful for the purpose of determining the magnitude of the changes in composition, which occur with the particular cycle and conditions of operation adopted during the tests described in this report.

In the description of the complete cycle of operations given in Section I. under the heading "Plant Routine," it was explained that immediately after clinkering the fuel bed was subjected to a two minutes "blow" followed by three minutes steaming in a downward direction and one minute in an upward direction. The generator was then charged with coke. This occupied about one minute and was followed by five six-minutes cycles of which the first, second, fourth and fifth each consisted of two minutes "blow" and four minutes up "run"; the third six-minute cycle including two minutes "blow," three minutes down "run," and one minute up "run." This 31 minutes cycle of operations from one coking to the next was carried out five times. During the sixth and seventh coking to coking periods, steaming was operated in an upward direction only. From one clinkering period to the next, therefore, there were eight distinct periods, one of six minutes before coking, six coking to coking periods each of 31 minutes, and one coking to clinkering period of 25 or 31 minutes.

Blue Water Gas.—In order to trace any changes in the composition of the blue gas made from one clinkering to the next, average samples were taken at the outlet of the generator during the first, third, and sixth of the eight periods just named. The samples taken did not include the gas made during the first few seconds of each run, since this gas would have included "blow" gas being swept forward through the generator. The results of analyses of the three samples are given in Table A.

TABLE A.

Period.	6 Minutes. (1) Immediately after Clinkering.	31 Minutes. (3) Coking to Coking.	31 Minutes. (6) Coking to Coking.
CO_2	6·2	5·1	5·1
O_2	0·0	0·1	0·0
CO	—	40·0	40 3

It will be seen from these results that the gas made during the first period, which included only one "run" of four minutes, contained more carbon dioxide than either of the other samples. This may be due to the fact that the fuel bed had lost heat during clinkering and that insufficient heat was generated during the first "blow" of two minutes to bring the fuel bed back to its average condition. From the analyses of the samples taken during the third and sixth periods, it may be concluded that a balance between the heat gained during each "blow" and lost during each "run" had been reached by the time of commencement of the third period, with the result that the gas made remained of approximately the same composition until the clinker was again removed from the generator.

The analyses given in Table B represent the compositions of the blue gas made during each of the four-minute "runs" in the same 31 minutes coking to coking period. The results show that the gas made during each "run" was of approximately the same composition.

TABLE B.—*Coking to Coking Period, 31 Minutes.*

Nature of "Run"	4 Mins. ↑	4 Mins. ↑	3 Mins. ↓ 1 Min. ↑	4 Mins. ↑	4 Mins. ↑
CO_2	4·2	4·7	4·6	4·6	4·6
O_2	0·0	0·1	0·1	0·0	0·1
CO	42·3	41·5	41 8	41·9	41·8

For the purpose of determining the change in composition of the blue water gas made during an individual up "run," four samples were collected in glass bulbs, at different times during the four minutes. The first sample was collected after steam had been passing through the generator for 20 seconds, in order to allow sufficient time for the operation of all valves and for "blow" gas to be swept out of the generator; the last sample was commenced 10 seconds before the end of the "run," and the second and third samples were taken at times intermediate between the first and fourth. An average time of about 7 seconds was required for collecting each sample. The results obtained, which are set out in Table C, show a

gradual increase in the carbon dioxide content of the gas from 1·2 p.ct. at the commencement of the "run" when the fuel bed was at the highest temperature to 11·0 p.ct. at the end of the "run" when the temperature was at a minimum.

TABLE C.—*Composition of Blue Gas at Different Stages of an Individual "Run." Four-Minutes up "Run" during Coking to Coking Period.*

Time of sample after commencement of "run"	20 Sec. to 27 Sec.	90 Sec. to 97 Sec.	160 Sec. to 165 Sec.	230 Sec. to 240 Sec.
CO_2	1·2	4·3	7·2	11 0
O_2	0 1	0·0	0·0	0·1
CO	49·3	42 1	37·0	31 8

Five samples were taken in a similar manner during a four-minutes "run" which included steaming in a downward direction for three minutes (less the time required for operating the valves) and in an upward direction for one minute. The first sample was not commenced until the "run" had been in progress for 35 seconds, in order to allow time for the operation of all valves including the steam reversing valves; it will be remembered from the description given under "Plant Routine" in Section I. that steaming must be carried out in an upward direction for a few seconds immediately after changing from "blow" to "run." Three samples were taken during the time of downward steaming and two samples during the last one minute of upward steaming. The compositions of the samples obtained (Table D) show a gradual increase in the carbon dioxide content of the gas made throughout the progress of the "run" from 1·4 p.ct. to 6·7 p.ct. during the down "run" and from 9·3 p.ct. to 11·6 p.ct. during the last one minute up "run."

TABLE D.—*Four-Minutes "Run" Including Down Steaming and One Minute Up Steaming.*

Time of sample after commencement of "run"	35 Sec. to 42 Sec.	100 Sec. to 107 Sec.	170 Sec. to 178 Sec.	185 Sec. to 192 Sec.	230 Sec. to 237 Sec.
Direction of steaming	↓	↓	↓	↑	↑
CO_2	1·4	2·7	6·7	9·3	11·6
O_2	0·2	0·1	0·0	0 0	0·0
CO	47·5	45·1	39·2	36·8	31·4

The results, in general, show the same characteristics as those obtained by fractional sampling on the blue water gas plant at the Adderley Street works and given in the Sixth Report.

"*Blow*" *Gas* (*Outlet Generator*).—The compositions of the "blow" gas leaving the generator at different stages of the process from one clinkering to the next were determined by analysis of samples taken by methods similar to those adopted in the case of blue water gas.

From analyses of average samples of "blow" gas made during the first, third, sixth, and eighth periods from one clinkering to the next (Table E), it may be seen that the "blow" gas made during the first "blow" immediately after clinkering was richer in carbon dioxide than the

TABLE E.

Period.	6 Mins. (1) Immediately after Clinkering.	31 Mins. (3) Coking to Coking.	31 Mins. (6) Coking to Coking.	25 Mins. (8) Coking to Clinkering.
CO_2	12·3	12·0	11·9	11·8
O_2	0·2	0 1	0·0	0·0
CO	12·7	14·1	14·0	14·2

"blow" gas samples taken during the later periods. These four samples, the first three of which covered the same period as the samples of "run" gas given in Table A, also lead to the conclusion that during the first "blow" after clinkering the fuel bed was below its average temperature owing to the heat lost when clinkering was in progress, but that a balance between the heat gained during each "blow" and lost during each "run" had been reached by the commencement of the third period.

The compositions of average samples of each "blow" of a coking to coking period are given in Table F. These analyses show that the percentage of carbon dioxide increased from the first to the third "blow" and then remained constant at 12·3 p.ct. until the fifth "blow," after

TABLE F.—*Coking to Coking Period, 31 Minutes.*

No. of "blow"	1	2	3	4	5
CO_2	10·8	11·6	12·3	12·3	12·3
O_2	0·1	0·1	0·0	0·1	0·1
CO	16·6	14·4	12·9	12·8	12·8

which the generator was recharged. The carbon monoxide content correspondingly decreased from the first to the third "blow," and then remained constant at about 12·8 p.ct.

Experiments were also carried out for the purpose of determining the changes in composition of the gas produced during an individual "blow" period. For this purpose five samples were taken, commencing 10 seconds, 20 seconds, 30 seconds, 70 seconds, and 110 seconds respectively after the change from "run" to "blow." The time occupied in taking each sample was about 7 seconds. The results obtained are given in Table G. The first sample probably contained a proportion of blue water gas. The gradual reduction in the amount of carbon dioxide and the

TABLE G.—*Compositions of "Blow" Gas at Different Stages of an Individual "Blow"*

Time of sample after commencement of "blow"	10 Sec. to 16 Sec.	20 Sec. to 27 Sec.	30 Sec. to 37 Sec.	70 Sec. to 77 Sec.	110 Sec. to 118 Sec.
CO_2	14·8	16·6	15·9	11·8	9·1
O_2	0·1	0·0	0·0	0·1	0·0
CO	9·2	4·5	7·5	14·1	17·6

increase in the amount of carbon monoxide as the "blow" proceeded are demonstrated by the remaining four samples, which show a fall in the proportion of carbon dioxide from 16·6 p.ct. to 9·1 p.ct. and a rise in carbon monoxide from 4·5 p.ct. to 17·6 p.ct.

The compositions of the fractional samples in general, therefore, confirm the results obtained in the more comprehensive investigation described in the second section of the Sixth Report.

APPENDIX I.

METHODS OF ANALYSIS.

The methods of analysis adopted were generally the same as those described in Appendix II. of the Fourth Report of the Gas Investigation Committee (Trans. Inst. Gas Eng. 1920, p. 307) and in Section III. of the Sixth Report (Trans. Inst. Gas Eng. 1921).

The amounts of sulphur in the samples of gas oil used for carburation and in the samples of tar recovered were obtained from determinations of the oxides of sulphur produced during the combustion of these substances in an atmosphere of oxygen in a bomb calorimeter of the Mahler-Kröcker pattern. The same bomb was also used for the determination of calorific values. For the purpose of determinations of sulphur a small quantity of water was first placed in the bottom of the bomb. One gramme of the sample to be examined was then burned in the usual manner in oxygen at a pressure of 25 atmospheres. After the combustion had been completed, the gas issuing from the bomb, on releasing the pressure, was made to pass slowly through a solution of potassium hypobromite free from sulphur. The bomb was washed out several times with distilled water, the washings being added to the hypobromite solution. The sulphur contained in this solution was determined by precipitation as barium sulphate, in the usual manner. This method of determination was used for oils and tars in place of the sodium peroxide method, which was used for coke, ashes, and clinker as described in Section III. of the Sixth Report.

The amounts of cyanide in the blue water gas at the outlet of the generators and in the carburetted water gas at the outlet exhausters were determined by means of alkaline ferrous hydrate in place of ammonium sulphide as used in the tests reported in the Fourth and Sixth Reports. It is known that carbon disulphide reacts with yellow ammonium sulphide to produce first ammonium dithiocarbonate and finally ammonium sulphocyanide. In presence of carbon disulphide, therefore, determinations of cyanide by

means of yellow ammonium sulphide yield results which are too high. Dr. H. G. Colman kindly wrote suggesting that possibly the small quantities of cyanide found in the blue water gas at the inlet of the scrubber during the tests at Adderley Street, Birmingham (Sixth Report), were the result of the interaction of carbon disulphide and ammonium sulphide. Experiments were, therefore, carried out by both the ammonium sulphide and ferrous hydrate methods for the purpose of determining the amounts of cyanide in the blue water gas entering the scrubber of the plant at Adderley Street. Determinations by means of ferrous hydrate invariably gave results equivalent to about 0·05 lb. of crystalline sodium ferrocyanide per 10,000 c.ft. of gas less than the results obtained with ammonium sulphide. It is possible that the figures obtained by means of ferrous hydrate may be too low, as the result of the conversion of cyanide in the presence of sulphur compounds into sulphocyanide, which would not be returned by this method. Further experiments were carried out at Adderley Street for the purpose of determining by both methods the amounts of cyanide in the blue water gas leaving the scrubber and at the outlet of the relief holder. The results proved interesting, since the ferrous hydrate method gave either no cyanide or only a trace, whereas ammonium sulphide gave results averaging the equivalent of 0·05 lb. of crystalline sodium ferrocyanide per 10,000 c.ft. of gas. Accepting the ferrous hydrate method as the more accurate, it may, therefore, be concluded that the small quantity of cyanide present in the blue water gas as it leaves the generator is almost entirely removed during the passage of the gas through the scrubber. The ammonium sulphide method is frequently used in ordinary practice, in connection with cyanide recovery, for the purpose of determining the amounts of cyanide in crude coal gas. In such case, the error which may result from the presence of carbon disulphide in the gas would be proportionately small; it is only when determining very small quantities of cyanide in the presence of carbon disulphide that the errors may become appreciable.

The method of carrying out the determination of cyanide by means of ferrous hydrate is as follows: The gas to be examined is passed slowly through four wash-bottles, each charged with a strong solution of ferrous sulphate made alkaline with a solution of sodium hydrate. At the end of the experiment, the solution obtained is filtered from ferrous sulphide and lead carbonate is added in small quantity to precipitate the last trace of sulphide. The filtered solution is acidified by the addition of sulphuric acid, after which it is distilled in the presence of a small quantity of cuprous chloride (Williams' method). The distillate is collected in aqueous caustic soda and the sodium cyanide formed is determined by titration with decinormal silver nitrate solution.

APPENDIX II.

DATA EMPLOYED IN CALCULATIONS.

The values given below have been employed in the calculations made in the preparation of the tables in this report.

Heat capacities in B.Th.U. per cubic foot (60° Fahr. (15·5° C.) and 30 in. moist). Heat capacity of water vapour in gas not included:

t = temp. ° C. *minus* 15·5.

H_2 and N_2	$0{\cdot}032t + 0{\cdot}0000187t^2$
O_2 and CO	$0{\cdot}0322t + 0{\cdot}00000231t^2$
CO_2	$0{\cdot}0418t + 0{\cdot}0000117t^2$
H_2S	$0{\cdot}0381t + 0{\cdot}00000468t^2$
CH_4	$0{\cdot}043t + 0{\cdot}0000453t^2$
C_mH_n	$0{\cdot}0723t + 0{\cdot}0000889t^2$

Heat capacities in B.Th.U. per pound:

$_{100}$ = temp. ° C. *minus* 100.
t = temp. ° C. *minus* 15·5.

H_2O (vapour)	$0{\cdot}915t_{100} + 0{\cdot}000215t^2_{100} + 1116$
Coke	$0{\cdot}414t$
Ashes	$0{\cdot}36t$
Tar (vapour)	$0{\cdot}80t + 180$

Calorific Values of Gases in B.Th.U. per Cubic Foot (60° Fahr. and 30 in. Moist).

Gas.	CO.	C_mH_n.	H_2.	CH_4.
Gross. . .	318	2659	320	992
Net . . .	318	2381	269	890

Calorific values (B.Th.U. per lb. gross) of ashes and clinker from ultimate analyses calculated from Dulong's formula:

$$\text{B.Th.U. per lb.} = \frac{14{,}544\ C + 62{,}028\left(H - \frac{O}{8}\right) + 4050\ S}{100}$$

in which C = carbon p.ct., H = hydrogen p.ct., O = oxygen p.ct., and S = sulphur p.ct.

Flow of steam through nozzles (*vide* Sixth Report, Section III.):

$$\text{Discharge in lbs. per minute} = 18{\cdot}93\ kA\sqrt{\frac{P}{V}}$$

in which k is the discharge co-efficient of the nozzle, A the cross-sectional area of the throat of the nozzle in square inches, P the initial steam pressure (absolute) in lbs. per square inch, and V the volume in c.ft. of 1 lb. of steam at pressure P. In the case of superheated or dry saturated steam, the volume V may be taken directly from steam tables, but if the steam be initially wet $V = x\ V_s$ in which V_s is the volume per lb. of dry saturated steam at pressure P and x is the dryness fraction. The formula can only be applied when the absolute pressure at the outlet of the nozzle is less than 0·55P.

APPENDIX III.

SUPPLEMENTARY DATA.

It is useful, when making comparisons of different types of plant or when considering new designs, to have approximate data for the make of gas per square foot of grate area, the time-contact of the gases in the fuel bed, etc. The following figures, not already included in this report, are therefore given as representing the approximate conditions which obtained in the tests carried out on the carburetted water gas installation at Windsor Street, Birmingham.

Generator.—(i.) Diameter of grate, 8 ft.; area of grate, 50 sq. ft.; distance from grate to coke charging door, 12 ft.

(ii.) Average make of blue water gas per minute, during "run" periods, per sq. ft. of grate area, 29 c.ft. (measured at 60° Fahr. and 30 in.).

(iii.) Average amount of steam supplied per minute, during "run" periods, per sq. ft. of grate area, 1·0 lb.

(iv.) Average time of contact of the gases with the fuel in the generator during "run" periods, about 2 seconds. This time was calculated on the assumptions that the average temperature of the fuel bed was 800° C. and that the actual volume of the fuel was equal to the volume of the interspaces.

(v.) Average volume of air supplied per minute, during "blow" periods, per sq. ft. of grate area, 124 c.ft. (measured at 60° Fahr. and 30 in.).

Carburettor.—(i.) Internal diameter approximately 7 ft.

(ii.) Dimensions of chequer bricks: base 10 in. × 2 in., top 10 in. × 1 in., depth 4 in., two curved sides. Rows of bricks placed 2¾ in. apart; number of courses, 17; total number of bricks, 1850 to 1900.

Superheater.—Internal diameter approximately 8 ft.

Waste Heat Boiler.—Velocity of gases through tubes, 44 ft. per second; time occupied in traversing tubes, 0·4 second. These figures are calculated on the assumption that the average temperature of the gases passing through the tubes was 400° C.

Prof. COBB, introducing the report, said: In making my statement a few minutes ago, I began by saying that the Gas Investigation Committee had undertaken two branches of work during the past twelve months. The second branch of work was an investigation of carburetted water-gas plant with waste-heat boiler; and a description of it, and the results obtained, form the Seventh Report. You will remember that after dealing with the steaming of the vertical gas-retorts at Uddingston, the Research Committee turned their attention to the production of blue water gas, and for that purpose investigated the working of a plant at the Adderley Street works of the Birmingham Corporation Gas Department. On analyzing this process it was pointed out that by far the most important loss was the potential and sensible heat in the gas leaving the generator, particularly during the blow, which pointed to a saving which might have been effected by the use of a waste-heat boiler. By making certain assumptions, it was possible to form some idea of what that saving might have been. But there was no waste-heat boiler attached to that particular plant; and we expressed the opinion that no really satisfactory quantitative estimate could be formed without making a test on an installation which included a waste-heat boiler. Fortunately the Birmingham Corporation Gas Department were able and willing to give us the opportunity we required, by placing at our disposal for the

purpose a Humphreys and Glasgow water-gas plant at Windsor Street, with an attached waste-heat boiler. It was a carburetted water-gas plant, and we took the opportunity of making the test not only on the waste-heat boiler, but on the efficiency of the carburetted water-gas plant itself. We were very pleased to do this because, although the production of blue water gas provides a ready means of gasifying coke and getting a larger proportion of the total heat of the coal into the gas, it necessarily produces a gas of low calorific value, which may lead to overburdening many existing distribution systems, and carburetting to the extent desired offers a means of adjustment. It is plain, too, from our results that the efficiency of gas production from oil is high, so that carburetting is on a sound thermal basis, if only the price of the liquid fuel cracked (whatever it may be) is brought sufficiently low.

A report on a subject of this kind necessarily resolves itself very largely into a description of the methods employed and a series of tables; and this report is no exception in this respect. Among experimental difficulties that had to be overcome, one of the chief was the measurement of temperature, which in a process with such rapid alternations as take place in a water-gas plant is no simple matter. It was shown that results as ordinarily obtained, by the use of a thermo-couple protected with a sheath, and calculations based upon them, are of more than doubtful accuracy. The consideration of efficiencies in this plant is complicated by the fact that there are three processes at work, each with its own efficiency—the manufacture of blue water gas in the generator, the addition of oil gas made in the carburettor and superheater, and the recovery of heat in the waste-heat boiler. The thermal efficiency of the whole process of manufacture taking the three together is 68 p.ct. higher than with blue water gas, partly because of the heat recovered by the waste-heat boiler, which brings up this efficiency by about 8½, and partly because the efficiency of the oil cracking is so high, amounting to some 90 p.ct. The efficiency of the generator alone was nearly the same as in the blue water-gas plant tested at Adderley Street. The amount of work and care involved in obtaining the figures used in the preparation of the numerous tables and balance-sheets has been very great—greater, I think, than ever before. Dr. Parker and his assistants (Mr. Kerr, Mr. Townend, and Mr. Howarth) are to be congratulated upon the way they have carried it through; and the Committee would like to thank them.

It was emphasized in dealing with the blue water-gas plant last year, and may be emphasized again, that the inquiry as we have undertaken it has been directed entirely towards the investigation of a plant, in this case of a carburetted water-gas plant, run under what we believe to be good normal works conditions. The question naturally arises as to what would be the effect of departing from these conditions in certain directions; and we have been granted facilities on the blue water-gas plant at Adderley Street for making some experiments of this kind with varying depths of fuel bed pressures, &c. These experiments are on the way, and we hope to deal with the results in our next report. I may say, however, that we regard the work done on the carburetted water-gas plant as requiring to be supplemented on the chemical side by a more exhaustive examination of the gas itself, the oils used, and the tars produced, which have, up to the present, only been examined by the conventional methods, which are in some cases not sufficient for our purpose.

Finally, may I say how much we have appreciated the continued hospitality and kindness which have been shown us by the Birmingham Corporation Gas Department and its officials. Mr. A. W. Smith (the General Manager), Mr. Foster (the Chief Engineer), Mr. Rhead (the Chief Chemist, and a member of our Committee), and Mr. Pearson, who has been in immediate charge of the carburetted water-gas plant, and proved himself a very zealous collaborator. With your permission, Dr. Parker, the Research Chemist, who is more responsible in detail for this piece of work than anybody else, will give a brief summary of it.

Dr. A. PARKER: You can see, from the length of the report, that it would be quite impossible for me to go into many of the points considered in it, so that I shall simply confine myself to giving a very brief outline of the work and the results, and how it is connected up with the work on efficiency of gas production previously carried out by this Committee.

This Seventh Report describes the third part of the inquiry into the comparative economies of production, from thermal and chemical standpoints, of different grades of gas by various processes. The inquiry was commenced by an investigation of the process of steaming the charges in the retorts of the Glover-West continuous vertical installation at Uddingston. The results of the Uddingston tests proved that, with proper control of the conditions, considerable advantages are to be gained by *moderate* steaming. It was found that the thermal efficiency of gas production rose from 54 p.ct. without steam to a maximum of 62 p.ct. with steam, and at the same time increased yields of tar and ammonia were obtained. In this matter I must point out that the steam in these tests was raised in a separate boiler, which was assumed to have an efficiency of 70 p.ct. It has since been calculated by the Research Committee that if the steam required for the retorts had been raised in waste-heat boilers (and it is probable that it could have been), the thermal efficiency of 62 p.ct. would have been increased to 68·5 p.ct. The results generally have since been confirmed by the work on this subject carried out at the East Greenwich Station of the Fuel Research Board.

The next step in the investigation, described in the Sixth Report, was carried out at the Adderley Street works of the Birmingham Gas Department, with the object of determining the efficiency of production of blue water gas as ordinarily practised in a plant without waste-heat boiler. It was found that, taking into account the steam required for the operation of the plant, the efficiency of production of blue water gas averaged 46 p.ct., and it was calculated that if the steam required during the process had been raised by means of a waste-heat boiler, the efficiency of 46 p.ct. would have been increased to 56 p.ct. The possible value of the waste-heat boiler was, therefore, at once demonstrated.

The work described in this Seventh Report has been carried out at the Windsor Street works of the Birmingham Gas Department for the purpose of determining the efficiency of production of carburetted water gas of a calorific value of about 458 B.Th.U. gross per c.ft. [I mention the calorific value, because the quality of the gas produced certainly bears a relationship to the thermal efficiency of the whole process.] At the same time, since the installation includes waste-heat boilers, data have been procured showing the amounts of steam raised and the resulting increase in thermal efficiency of the whole process. Throughout the tests, the usual routine for the particular installation was adhered to almost entirely, since the object of the investigation was to examine the process of manufacture of carburetted water gas as ordinarily practised. To avoid undue interference with the town supply, tests involving serious alteration in the methods of operation were not attempted. Perhaps I might remind you at this stage of what Prof. Cobb said about the tests at Adderley Street. We have obtained permission to make certain tests in regard to the operation of blue water-gas plants, and that work is now in progress; but in the case of Windsor Street, we have kept practically to the ordinary routine. According to the practice adopted at Windsor Street, clinkering was carried out every four hours. The generators were charged with fuel to a depth of about 8 ft. 9 in. every 31 minutes, and the usual cycle consisted of two minutes "blow" followed by four minutes steaming in an upward direction. Occasionally the four minutes steaming included three minutes in a downward direction, and one minute in an upward direction. During the one hour preceding clinkering, steaming was carried out in an upward direction only. Oil was admitted to the carburettors at a steady rate during the first three minutes of each run. The results of the tests, which, together with thermal and carbon balances, are given in detail in the first section of the report, show that the thermal efficiency of the whole process of production of carburetted water gas of a calorific value of 485 B.Th.U. averaged 68 p.ct. This figure of 68 p.ct. has been derived after taking into account the steam raised in the waste-heat boilers and the steam required for the generators, blower, exhausters, oil pump, and boiler-feed pump. If the steam required for the plant had been raised externally in boilers with 70 p.ct. efficiency, the efficiency of the whole process would have been only 59·5 p.ct., so that the waste-heat boilers have resulted in an improvement of about 8·5 p.ct. The efficiency of production of blue water gas in the generators of the carburetted plant, without taking into account the steam required or raised, was 53 p.ct. Taking into account the differences in the methods of operation, this figure of 53 p.ct. for blue gas is in agreement with the corresponding figure of 56 p.ct. given in the Sixth Report. The efficiency of production of oil gas during the "cracking" of the enriching oil was approximately 90 p.ct., and it is this high figure which has caused the efficiency of the whole process to be as high as 68 p.ct., although the blue water gas was produced in generators with a corresponding efficiency of only 53 p.ct. It is clear, therefore, that in stating the efficiency of production of carburetted water gas with a particular enriching oil, it is necessary to state the quality of gas produced, for the over-all efficiency will be dependent on the amount of oil gas admixed with blue water gas. With smaller quantities of oil than those used during the tests, the over-all thermal efficiency would be lower than 68 p.ct. With larger quantities, the efficiency would be greater than 68 p.ct. so long as sufficient heat were available in the blow gases leaving the generators to heat up the carburettors and superheaters to an efficient "cracking" temperature.

The waste-heat boilers of the installation are of the fire-tube type—*i.e.*, the hot gases travel through metal tubes, and the water is on the outside. Waste gas only is allowed to pass through the boilers, which are out of circuit during the "run" periods. The thermal balances of the waste-heat boilers show that during the tests the total heat of the steam raised averaged only about 45 p.ct. of the heat entering the boilers. The amount of steam raised, about 64 lbs. per 1000 c.ft. of carburetted gas made, was, however, sufficient to supply the generators, blower, and auxiliary plant. It is pointed out in the report that the low thermal efficiency of the boilers might be improved by more satisfactory means of burning the combustible gas leaving the superheaters during the "blow" periods. The boilers were cleaned out by flushing with water every two or three months. For this purpose it was necessary to shut-down the whole of the plant, since no means is provided for bye-passing the boilers during the operation of the plant. It would certainly be an improvement if a convenient arrangement could be made which would enable the boilers to be shut-down when necessary without interruption of gas making. No trouble was experienced from leakages of water between the fire-tubes and the tube plates; but it is believed that

absence of trouble from this cause was due to the care taken in cooling the boilers for two or three days before cleaning.

It will readily be understood that, when carrying out tests on an intermittent process such as the manufacture of water gas, it is no easy matter to obtain representative samples of gas at the several points of the plant. It has been necessary to adopt different methods at different points. Attention is specially directed to the diagrammatic sketch in diagram IV., which illustrates the apparatus used for the examination of the blue water gas leaving the generators. This apparatus, which is explained in the first section of the report, is controlled by mercury U-tube valves working in conjunction with the operating valves of the plant—that is to say, as the operator moves his change-over valve and valve for turning on steam, it automatically operates the sampling apparatus at the same time, so that samples may be drawn over continuous periods—say, twenty-four hours—without the necessity for having the men on the shift doing nothing but turn on taps.

In the Sixth Report, reference was made to the trouble caused in the manufacture of blue water gas by the deposition, in a finely divided condition, of a yellow-brown powder, which contained free silica and sulphur. During the test on the carburetted plant at Windsor Street, no trouble was caused by any similar deposit, although it was clear from experiments carried out at the outlets of the generators that a similar dust was carried forward to the carburettors by the blue water gas made. The dust must therefore have been removed from the gas during passage through the carburettors and superheaters; or it was carried away by the tar which condensed out afterwards. This matter is still undergoing further investigation.

Special investigations were also carried out for the purpose of determining the temperatures of the gas entering and leaving the waste-heat boilers. The intermittent nature of the process, and the consequent rapid changes in the temperatures of the gases produced, rendered these investigations necessary, for without extraordinary precautions even approximate readings cannot be obtained, and it would be impossible to obtain temperature readings accurate enough to be used in the construction of thermal balances. For example, with the usual pattern of iron-sheathed pyrometer, the average of the temperatures of the gases leaving the waste-heat boilers during the "blow" periods was approximately 60° C. lower than the average temperature obtained under similar conditions with a bare platinum—platinum-rhodium thermo couple. This discrepancy was due entirely to the difference in lag of the pyrometers. This subject of temperature measurement is discussed in the second section of the report, and typical curves are given. The results of an examination of the changes occurring in the compositions of the "run" and "blow" gases at different points of the "run" and "blow" periods are also included in the second section. The methods of analysis adopted, data employed in calculation, and certain supplementary data are given in the appendices at the end of the report.

Discussion.

The PRESIDENT: You have had these introductions by Prof. Cobb and Dr. Parker, and I now formally move the adoption of the report. In doing so, I should like to repeat the acknowledgment that has already been made to the Birmingham Gas Committee and to the officials of the Birmingham Corporation for the facilities they have given to our Research Committee for carrying out this work. There is a large number of undertakings now with water-gas plants; and I am sure that the figures which are given in the report are of the greatest interest to all of us. Many of you, I have no doubt, will be very glad indeed to have had an opportunity of raising questions on it. The report, therefore, is now open for discussion.

Mr. J. P. LEATHER (Burnley): I shall be glad to second your motion, Mr. President, for the adoption of the report, and to express my appreciation of the work of the Committee, and of those who have carried out this Research, which has certainly, as anyone who reads the report carefully will find, added considerably to the information which we have previously had on the efficiency, from a thermal and chemical point of view, of a carburetted water-gas plant. I should just like to make a suggestion with regard to one part of the report, and that is the question of the oil. Mention is made, for instance, of the thermal efficiency of the oil-gas production part of the process being 90 p.ct. It sounds pretty high, but, of course, that is not a commercial efficiency—it is an efficiency taking into account the heat value of the tar, and so on, produced from the oil. For instance, the carbon in the oil is only 60 p.ct., and there is 21 p.ct. of the carbon in the tar; so that there is still room, so far as the question of making oil into gas is concerned, for considerable improvement. I do not mean to say necessarily that it is impossible; but the efficiency is not 90 p.ct. when viewed from the point of view of how much oil is being made into gas. There is included in the report a table of distillation tests of oils; and I want to make this criticism—that it would have been very much more interesting, at any rate to me, if there had been something added to that table. I think considerable information would be given as to the nature of the oil and the possibility of gasifying it, if, in addition to a mere table of percentages in relation to boiling point, we had the specific gravity of the fractions. The specific gravity of the whole of the oil is given, but that is not quite sufficient to give an indication of the nature of the oil. I believe Prof. Cobb, in his introduction, did make some little reference to the possibility of having more information as to the nature of the oil. The oils on the market for carburetted water-gas plants are, of course, produced from natural sources by distillation and have very varying qualities and chemical composition. If an oil consists of compounds which are almost entirely of a cyclic character—for instance, compounds having the double naphthalene ring with a small amount of side chain, a simple hydrogenated naphthalene—it gives very little result in the form of gas, although you may produce plenty in the form of naphthalene. The reference to naphthalene in the report is very interesting, when one remembers that a number of years ago it used to be stated that you would get over naphthalene troubles if you had a carburetted water-gas plant. My experience is that it is possible to have a larger quantity of naphthalene in your water gas than in coal gas. The question of the chemical character of the oil is a very different one, and this, no doubt, was why it was not entered into in this report; but the relationship between the gravity and the boiling point of the different fractions would have imparted very considerable information as to the chemical character of the oil, which might be supplemented by the refractive indices of the fractions. The relation of the gravity and the boiling point gives a good indication of the nature of the oil, what proportion is in the form of a ring, and what proportion in aliphatic chains. I hope that in future, when the Research Committee give any analysis of oil, they will supply further information in this way. I have very great pleasure in seconding the adoption of the report, and in expressing my appreciation of the work of the Committee.

Mr. C. F. BOTLEY (Hastings): I regard this as another very valuable contribution to the work of the industry, and one which again justifies the Research Committee, and the able assistance of the Leeds University and its Staff. There are just one or two points in the report which strike me, and in many ways, perhaps, it will establish, or help us to do so, the standardization to which the President referred in his address as very necessary if we want to keep ourselves tuned in regard to results. The report has, in my view, one very great merit, and that is the results given of tests made on a plant running under practically daily working conditions. Many of us have suffered great humiliation and heartburnings in the past when we have tried to achieve results in practice which have been arrived at on specially tuned-up plant, and sometimes these special results are very harmful. Here we have results which are obtained under practical conditions, and therefore they establish a standard which those of us who use plants of the nature can endeavour to achieve, and perhaps some of us can more than achieve them. With regard to the waste-heat boilers, which establish an increased efficiency of 8 p.ct., or thereabouts, the information is valuable in two ways. First of all, it will enable us to gauge the commercial value of waste-heat boilers in connection with any plant; and, also, attention is very properly called to the necessity of a bye-pass arrangement, because in some cases it would be very awkward to have to shut down a plant because you wanted to deal with the boiler. I take it from the report that there has been no trouble in the operation of the particular boiler—I mean with regard to accidental mixtures or want of ignition. There is another point, and it touches on the question of naphthalene. I cannot help feeling—and I speak with all diffidence—that in looking after the waste-heat boiler there has certainly been a temperature maintained in the superheater which should not be necessary for the complete cracking of the small amount of oil necessary to produce gas of 485 B.Th.U. This I say with all diffidence—it is only a suggestion which comes into my mind. Certainly naphthalene can be produced very freely by wrongly cracking an oil; and in this direction possibly further investigation will be very helpful indeed to us. There is another remark in the report which I welcome very much, because I find the same difficulty myself, and that is with regard to the chemical analysis. It has helped me in regard to a difficulty that I have experienced. With the ordinary methods of analysis, one has got rather low results for hydrogen and high for methane. I noticed this in the report when reading some observations on the tests, which are very useful, among many others in this most excellent report. I, too, think that we are to be congratulated on having the continued assistance of the officials of the Birmingham Corporation.

Mr. H. R. S. WILLIAMS (Altrincham): I must associate myself with the other speakers who have remarked on the extreme utility of research of this description. Unfortunately, I have not had an opportunity of reading the paper carefully; but it struck me, in looking at the diagram and reading the paper casually, that the carburetted water gas was not led through the boiler. I should like to ask Dr. Parker why that was not done. I notice that its temperature was approximately the temperature of the waste gases from the blow; and it seems that better results could have been obtained by using the waste heat from the gas itself.

Mr. THOMAS GOULDEN: I should like to add my congratulations to the authors of this very instructive report, and express my personal appreciation of the work they have done. I consider it most valuable. Mr. Williams spoke as to why no boiler had

been fitted for the carburetted water gas. I took that into view in considering the subject of waste-heat boilers some time back. I did not instal them, because up to the time of the Birmingham tests two boilers had always been used—that is to say—where they had been fitted—in America. No such had been fitted to carburetted water-gas plants in this country, and the reason I abstained from fitting a boiler for carburetted water gas was because of the difficulties arising from tar deposit in the tubes. All sorts of troubles arise in regard to this particular arrangement. There is an additional need to convey our congratulations to the authors of the report, because they show that by the action of the blast gases alone, which are clean gases, we can raise enough steam for the whole service of that particular line of plant, and still have a surplus. The low efficiency of the boiler has been referred to as affecting the total efficiency. Of course, 45 p.ct. is a low efficiency, but unless we are going to have very large boilers indeed, and very much increase the cost of installing them, I think we must be satisfied with low efficiency. You must recollect that you are making your steam in only two minutes of the total cycle; and obviously this must affect the efficiency materially. I should like to see obviated the necessity for shutting down the whole plant when you want to deal with the boiler. I know it somewhat complicates the connections, but it can be done. In large installations the difficulty can be got over. We are likely to do it—and the President may be able to tell you something about it—by coupling a boiler up to two sets, or two boilers to two sets, so that we can interchange the plant, and if we have one boiler down we can work the other. As to the dust nuisance, I do hope that more research will be carried out, and that we shall hear more from the scientific gentlemen as to the origin, and, if possible, as to the elimination of this dust. It is a dreadful nuisance, and it would be all to the good if we could obviate it.

With regard to naphthalene, you must recollect that we must have a certain temperature to deal with gas in the superheater; and the more oil we use, the higher we are compelled to raise the temperature. We certainly have experienced difficulties in the shape of naphthalene from oil-gas manufactured on the works. I recollect that in the early days of carburetted water gas we had considerable difficulty, but that arose entirely out of the somewhat inefficient condensers generally put in by the makers when installing oil-gas plant; and if anyone wants to avoid difficulties with naphthalene arising from carburetted water-gas plant, I should strongly recommend him to look to his condensers.

Mr. GIBSON (Liverpool): Dr. Parker mentioned 100 B.Th.U. per gallon of oil used. This figure, of course, will depend on the quality of the oil used. I take it that the oil used at Birmingham was standard American gas oil. Mr. Leather has referred to the table of distillation tests on p. 40 of the report. It seems to me that tests such as these do not really give a true indication of the value of oil for gas making in the carburetted water-gas plant. We are endeavouring at Liverpool to set-up an apparatus for testing oil in the laboratory more in accordance with working conditions; and I think Mr. Leather has also done something in that respect. We are hoping to get comparative results from these tests which will give us a more approximate indication of what the oil will do when in use. The report will be a valuable one for reference; and these figures as to efficiencies are very useful indeed.

Mr. CROSS (Lea Bridge): The value of the paper is that for each individual some little question arises. I have had the pleasure of seeing the plant at work at Windsor Street, and on seeing it work I decided (or my Board did, on my recommendation) to put-down a waste-heat boiler. A question I meant to ask Dr. Parker is this. To what extent, during the course of his tests upon that plant, was the steam from the ordinary boiler cut-off, because if you have the steam from the ordinary Lancashire boiler connected to the waste-heat boiler the test is not quite convincing?

Mr. C. H. CARDER (Oldbury): I wish to add my appreciation of the work that has been done. There are two points which appeal to me particularly; and they are totally dissimilar. The first is the extremely low steam pressure employed on the plant for the generation of blue water gas. The paper gives a pressure in the neighbourhood of 88 and 90 lbs. per sq. in. Although I fully realize that this is within the neighbourhood of the steam pressure usually specified by the makers of the plant, it is quite impossible to get dry steam directly generated at that pressure, and therefore impossible to get efficient conversion of the steam into blue water gas. There is a very needless absorption of heat in producing water vapour. Some years ago I made some experiments on the question of superheating the steam; and I have in my own case cut-out all lower-pressure steam for water-gas generation, and am using steam of 160 lbs. per sq. in., *plus* 100 to 150 degrees superheat. I am fully convinced that on results this pays. The other point is in connection with the waste-heat boiler. In the first place, full advantage was not taken of the heat recovered from the condensation of the gases by the utilization of the hot water from the condensers for boiler feed, and secondly 40 p.ct. of the available thermal efficiency of the blow gases was sent to waste, as the analyses of the gases leaving the waste-heat boiler showed that they still contained over 4 p.ct. of carbon monoxide. If it were possible for the Corporation to give facilities for a further test of the waste-heat boiler to its maximum efficiency, by absorbing the surplus steam which would be generated into their ordinary works mains, it would be most interesting to have a comparative efficiency table brought down to technical efficiencies, or, if possible, to a comparison of operative costs, showing, on the one side, the increase in efficiency obtained by working the waste-heat boiler to the maximum efficiency available from the blow gases produced, and, on the other side, the effect of cutting-out the waste-heat boiler altogether, and so readjusting the period and pressure of the blast as to generate only sufficient heat for the maintenance of the proper temperature for oil cracking and fixing, taking credit for the increased fuel efficiency on blue water-gas generation thereby obtained.

Mr. F. H. ROBINSON (Harrogate): I think there is a discrepancy between where it says that the lag of the sheathed couple was one minute and the diagram where the temperature is indicated half-a-minute after the closing of the valve. In my experience I have found that a sheathed iron-constantan couple shows a lag of half-a-minute. The explanation we gave to that was not so much the sheathing as the distance of the thermo-couple from the generator. In the plant described in the paper, there is a considerable distance between the carburettor and superheater, and that is some distance away from the generator. In my own case we have only a short distance; and I suggest to Dr. Parker that perhaps some of the lag may be due not so much to the sheathing as to the distance of the thermo-couple from the generator. With this exception I think the report as a whole is really a wonderful piece of work, and shows great care on the part of the experimenters.

Dr. A. PARKER: I must first thank the meeting for the very interesting discussion, which shows that great interest has been taken in the paper. With regard to the different points raised, Mr. Leather referred to the results of the distillation tests given in the report. We have given the results as obtained by the usual standard distillation in the 100 c.c. Englen flask; but I think it should be clear that this is not really a fractionation. It is a small flask with rather a long neck and side tube, but not in the nature of a fractionating column, and does not really divide the oil up into its different constituents very efficiently. It is because of the difficulty of representing such a distillation efficiently that the specific gravities were omitted at this stage. It is a standard method for the examination of oils in the petroleum industry. We are carrying out experiments with the object of finding out more about the oil used in these particular tests. For example, we have to fractionate the oil very carefully several times and examine each fraction. We are using 12-pair columns and other types of fractionating columns, and examining the specific gravity and the behaviour of each fraction towards sulphuric acid, caustic soda, and other re-agents, in the hope of finding out the proportion of paraffins and naphthalenes. To anyone who has tackled the subject, it is clear that it is not a matter that can be solved quickly; and we had not the time to do it in order to be ready for this report. I was speaking to a man the other day about tar distillation and the examination of petroleum oils, and pointed out that we could not determine the exact amount of each constituent. I said it would be a matter of several years' research, and it was not of such immediate interest to the industry as other problems. He replied: "You mean several lifetimes, not several years." It is something akin to the determination of the constitution of coal. I am not aware that anybody yet has really given an exact constitution of any petroleum oil. The general belief is that American oil consists mainly of paraffins; and I think a good many engineers, perhaps, are under the impression that this means probably 90 p.ct. From the little work we have done so far, I should be rather surprised if we got anything more than (say) 70 p.ct. paraffins. There is not such a huge difference between the oil from one district and that from another as to say that one consists almost entirely of paraffins and the other almost entirely of naphthalenes. One or the other may predominate: but it is a matter we are examining at the moment, and it will involve a good deal of work. The refractive index and possibly the optical rotary power of the different fractions may also be considered, but I cannot say at this stage how much information we shall be able to derive from that.

With regard to the efficiency of the oil, in calculating efficiencies of a process one must decide on a particular method. It is quite obvious that the efficiency of a process will vary according to the point of view taken in making the calculation. We have adapted thereto the principle defined in the Clark-Smithells-Cobb report—that is, we are taking the heat in the oil and dividing it by the sum of the heat in the gas *plus* the heating value of any useful products. We shall attempt to decide on the relative value of the tar recovered, which is sold, and gas recovered. If you cut out, in determining the efficiency of production of coal gas in the vertical retort, the heat value of the tar and all other products of that nature, you would get a figure of 25 p.ct. for the efficiency of gas production, because you have only 25 p.ct. of the heat value of the coal in the gas produced. But we produced coke and tar, and took these into account. We adopted the same principle in calculating out the thermal efficiency of production of oil gas and although we have given this figure of 90 p.ct., it is clear from the tables that the heat in the oil gas produced is really only about 70 p.ct. of the heat in the oil. But, allowing for the heat in the tar, we get an efficiency of 90 p.ct.

Mr. Botley referred to the cracking temperature in the superheater. I believe his point was that he did not consider we required a temperature so high in the superheater as we used for

the efficient cracking of the small quantity of oil used. It is rather difficult to say, unless we carry out a large number of tests using the same consumption of oil and different cracking temperatures. We have been guided by years of experience with this class of oil at Windsor Street, and have employed a test commonly used in practice—namely, the paper test, examining the deposit of oil and carbon on paper on to which a jet of the gas is allowed to impinge, and so on. We did not lift the temperature of the superheater with any idea of increasing the efficiency of the waste-heat boiler; we merely took the temperature which we believed approximated to a good efficiency. I cannot say it is the best without further test. As to naphthalene, we have pointed out the amount in the gas leaving the exhausters. We had no real trouble from naphthalene; but it is pointed out in the report that much may have been present at that point. The naphthalene in the gas leaving the purifiers was less than one grain. There is certainly a large amount of naphthalene produced, but I doubt whether much real systematic work has been done on this point. Mr. Botley raised the difficulty of trying to balance the hydrogen in the carburetted water gas with the total hydrogen in the blue water gas. We adopted the conventional method of analysis. We are going into that to try to present the figures in a more scientific way, or (I should say) in a more exact form; but it is quite possible, even though we may have less hydrogen in the carburetted water gas than in the original blow gas, that a certain quantity of the hydrogen in the blow gas is used up in saturating certain of the unsaturated compounds produced from the cracking of the oil. It may hydrogenate some of the compounds, and thereby some of the hydrogen in the blow gas is used up.

Mr. Williams asked why carburetted water gas was not passed through the boiler. Of course, we took the plant as it was. We could not pass carburetted water gas through the boiler; and I think probably the makers were right, because the deposit of tar and emulsion would undoubtedly (I should imagine) cause a great deal of trouble in the working of the boiler, and if it contained a small proportion of tar acids it might have a detrimental effect on the fire tubes. Mr. Goulden referred to the tar deposits, and also the low efficiency of 45 p.ct. This is a point as to whether it would pay to increase the surface area of the boiler to get a bigger efficiency; but I believe, in this particular case, the efficiency of the boiler could be improved even with the same surface area. The low efficiency is partly due to the fact that we have not a proper mixing and combustion of the gases before entering the boiler tubes. We lose a certain amount of potential heat in the form of carbon monoxide and hydrogen, so that we may possibly get improvement even with the same size of boiler.

Mr. Gibson referred to the statement as to the enriching power of the oil being 100 B.Th.U. per gallon—that is, 1 gallon per 1000 c.ft. of carburetted water gas increased the quality of the blue water gas made by 100 B.Th.U. Of course, that figure (I think I pointed out) could only be applied provided you had the same cracking efficiency and oil of the same calorific value. I did not suggest that it be applied without a certain amount of experience with the oil you are using and the particular amount of carburetting. It may not apply if you use three or four gallons of oil, because you may not have the same cracking efficiency. He also referred to the distillation tests, and the fact that he is carrying out small-scale tests for cracking efficiency. I agree with his remarks; but possibly an apparatus may be devised for testing the enriching value of an oil on a small scale. As far as I understand, there are several works in the country carrying out experiments on these lines. I know that Birmingham is experimenting; and I have seen experiments tried elsewhere. Possibly such tests can be devised. They would certainly prove useful. The other points referred to I think I have already answered in reply to Mr. Leather.

Mr. Cross asked how far the steam was shut-off from the Babcock and Wilcox boiler plant during the test. These boilers were shut-down altogether, and all valves closed; and we ran the plants with the waste-heat boiler. The other boilers were shut-down entirely, and firing stopped, and the valves were carefully examined to see that no leaks occurred.

Mr. Carder referred to the low pressure of steam passed into the generators. I may be wrong, but I think, for ordinary practice, the pressure of steam we used was about 88 lbs. At any rate, it was certainly an average figure; and I do not think it was below the average. As regards any advantage to be gained by superheating the steam, I cannot give any information on that point. It would require tests to determine the efficiency of the superheater, and whether the benefit derived would be worth superheating the steam for. We did not supply the waste-heat boilers with preheated water from the condensers, simply because the water leaving these condensers fluctuated too much in temperature, and would have prevented accurate measurement, whereas we had a more constant temperature by supplying direct from the well. But I do not think it affects the thermal balances in any way. In working out the efficiency of the oil process, we have taken into account the heat value of any steam raised in excess of that required for operating the plant according to the original definition.

Mr. Robinson referred to the lag of the pyrometer. I am not clear as to his point, and I should like to discuss it with him afterwards. What we mean by lag is that if we place two pyrometers in a gas stream in the same position, the one with the least lag will attain the actual temperature of the gas much more quickly than the other pyrometer with the greater lag. If we take a thin, directly exposed, platinum—platinum-rhodium couple it will attain the actual temperature of the gas much more quickly than the bare or sheathed iron-constantan couple.

THE BENEVOLENT FUND MEETING.

THE first business dispatched on the second day (Wednesday) of the Institution Meeting last week was the adoption of the report and accounts of the Benevolent Fund.

The PRESIDENT asked the Hon. Secretary to read the minutes of the last meeting.

The HON. SECRETARY (Mr. Walter T. Dunn) read the minutes, and they were confirmed.

The PRESIDENT: I will now ask the Secretary to read the report. It is a very short one; and I think we may as well have it read.

The HON. SECRETARY then read the report, which will be found on p. 558 of the "JOURNAL" for June 7.

The PRESIDENT: I beg to move the adoption of the report, and also of the accounts. During the year, the income has been well maintained; and it has been a great pleasure to the Committee to be able to increase their grants. They also gratefully acknowledge the gift of £100 received from Mr. F. J. North in memory of his father, the late Mr. William North; and this has been specially referred to in the statement.

Mr. C. F. BOTLEY (Hastings): I have pleasure in seconding the adoption of this report; and in doing so, I should like to mention how much the Committee, in dealing with grants, are indebted to visitors who go to the various cases. It is desirable that these visitors should know—apparently they have not realized it in the past—that if there is need for further assistance, the Committee are always willing to consider such cases; and I believe this time they have done so voluntarily. I think it is the fact that the actual subscriptions are less than what we are giving away; and this will be more marked in the current year. This being so, if we are to keep up these payments, and also have something "up our sleeve," so to speak, to meet unexpected calls, it will be necessary not only to maintain, but to increase, the present subscriptions that members are good enough to send to the fund. I have been associated with the Management Committee of the fund for some time now; and I can say without hesitation that the cases brought to the notice of the Committee are dealt with fairly and in my opinion adequately. I believe the fund proves a great blessing in many instances. There was one extremely painful case just recently. I do not remember the exact details, but I do recall one feature of it—that the deceased (whose family were in very great distress) had been a subscriber to the Benevolent Fund. It is not always the case that the head of the family who receive benefit has been a subscriber. That never weighs with the Committee in dealing with the cases that come before them. I only hope the good work may continue in the future as it has gone on in the past.

The PRESIDENT: If nobody has any remarks to make, I will put the resolution to the meeting.

The report and accounts were then unanimously adopted.

The PRESIDENT: The next thing is to announce the election of two members to the Committee of Management, to succeed those retiring in rotation. The Scrutineers have reported that Mr. R. E. Gibson, of Liverpool, and Mr. E. G. Hutchinson, of Richmond (Surrey), have been elected as the two new members. If there is no other business, that concludes the proceedings at this meeting.

INSTITUTION GAS RESEARCH FELLOWSHIP, 1922.

THE LIBERATION OF NITROGEN AND SULPHUR FROM COAL AND COKE.

By A. C. MONKHOUSE, Ph.D., B.Sc. (Institution Gas Research Fellow), and J. W. COBB, C.B.E., B.Sc. (Livesey Professor).

I. THE LIBERATION OF NITROGEN (*continued*).

In our previous report (1)* we showed that:

1.—With a soft coke prepared at 500° C, the action of hydrogen resulted in a considerable attack on the nitrogen present in the coke and the formation of considerable quantities of ammonia.

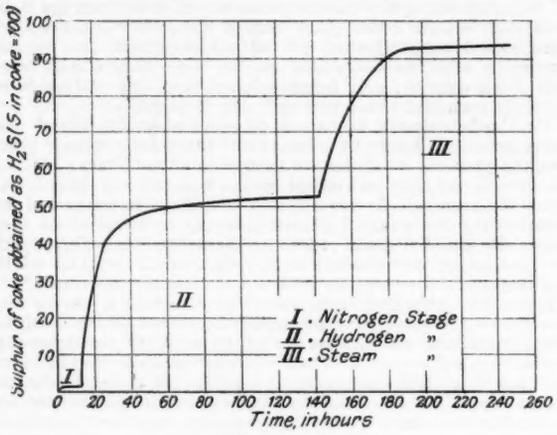


Fig. 12.—500° Coke.

2.—With a medium (800° C.) coke, the attack of hydrogen was less extensive and the ammonia recoverable smaller.

3.—With a hard (1100° C.) coke, hydrogen had no power of attack.

4.—With the 500° C. coke, the nitrogen could be removed at 800° C. in three stages—a portion in a current of nitrogen, a second portion in a current of hydrogen, and the remainder in a current of steam. In this last stage the whole of the coke was burned to ash. The whole of the nitrogen lost from the coke was obtained as ammonia in Stages II. and III.; but in the first stage two-thirds of the nitrogen evolved appeared as free nitrogen, and one-third as ammonia.

5.—This loss of free nitrogen in Stage I.—*i.e.*, on heating the 500° C. coke to 800° C. in nitrogen—was not materially diminished by raising the temperature of the coke slowly in stages of 100° to 800° C.

The next question that arose was how far the production of free nitrogen instead of ammonia could be obviated by using hydrogen or steam throughout instead of nitrogen.

An experiment was made in which the 500° C. coke was raised in stages in a current of hydrogen. The temperature was raised to 500° C. and maintained there, then subsequently to 600° C., 700° C., and 800° C. The coke was maintained at each successive temperature for a period of approximately forty hours; and the results are indicated in fig. 13.† A sample of coke was then withdrawn for analysis, and a nitrogen balance-sheet constructed. The short dotted lengths of the curve indicate the change from one temperature to another, and were obtained by extrapolation. The treatment was afterwards continued to 900° C. and to 1000° C.; balance-sheets being drawn up for both of these temperatures.

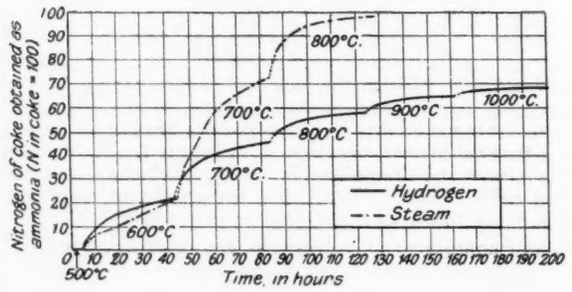


Fig. 13.—500° C. Coke.

EXPERIMENT 10.—*500° C. Coke Raised in Temperature Stages of 100° from 500° C. to 1000° C. in a Current of Hydrogen.*

Weight of coke taken . . . . = 19·549 grms.
Nitrogen in coke . . . . . = 1·87 p.ct.
Average rate of flow of hydrogen . = 4·5 litres per hour.

NITROGEN BALANCE-SHEET AT 800° C.
(500° C. coke, using hydrogen.)

10*a*. Calculated to 500° C. coke—
Nitrogen obtained as ammonia—

		Per Cent.
1. 500° C.	0·38	
2. 600° C.	20·85	
3. 700° C.	24·18	58·6
4. 800° C.	13·21	
Nitrogen left in the coke		32·3
Nitrogen unaccounted for (free nitrogen)		9·1
		100·0

10*b*. Calculated to original coal—

Nitrogen driven off in various forms during coking	21·6
Nitrogen obtained as ammonia	46·0
Nitrogen left in the coke	25·3
Nitrogen unaccounted for (free nitrogen)	7·1
	100·0

If this result is compared with that of Experiment 9 of the 1921 Report, it will be seen that the free nitrogen has been diminished from 14·6 to 9·1 p.ct. by heating in hydrogen instead of nitrogen, but not eliminated.

By taking this coke from 500° C. to 800° C. in nitrogen, and subsequently heating at 800° C. in a current of hydrogen, a yield of 56·7 lbs. of ammonium sulphate per ton of original coal had been obtained [Experiment 7, 1921 Report].

[NOTE.—In this figure of the yield of ammonium sulphate no account is taken of any ammonia obtained in the preliminary coking to 500° C.]

But now the coke being raised to 800° C. in stages, and during the whole period maintained in a current of hydrogen, a yield of 81·0 lbs. of ammonium sulphate per ton of original coal was obtained. This represents the maximum result so far obtained without the use of steam. There was still left in the coke at this stage of the experiment 32·3 p.ct. of the nitrogen of the 500° C. coke. The quantities of ammonia obtained in short periods of heating can be read from the graphs.

NITROGEN BALANCE-SHEET AT 900° C.
(500° C. coke, using hydrogen).

Calculated to 500° C. coke—
Nitrogen obtained as ammonia—

		Per Cent.
1. Up to 800° C.	58·6	
2. Extra to 900° C.	6·5	65·1
Nitrogen left in the coke		20·6
Nitrogen unaccounted for (free nitrogen)—		
1. Up to 800° C.	9·1	
2. Extra to 900° C.	5·2	14·3
		100·0

Raising the coke to 900° C. in hydrogen therefore removed a further 11·7 p.ct. of the nitrogen of the coke, of which 6·5 p.ct. was obtained as ammonia. The nitrogen left in the coke at this stage was 20·6 p.ct. of that originally present.

NITROGEN BALANCE-SHEET AT 1000° C.

Calculated to 500° C. coke—
Nitrogen obtained as ammonia—

		Per Cent.
1. Up to 900° C.	65·1	
2. Extra to 1000° C.	3·1	68·2
Nitrogen left in the coke		11·2
Nitrogen unaccounted for (free nitrogen)—		
1. Up to 900° C.	14·3	
2. Extra to 1000° C.	6·3	20·6
		100 0

Thus a further 9·4 p.ct. of the nitrogen of the coke was removed on raising the temperature from 900° C. to 1000° C., of which 3·1 p.ct. was obtained as ammonia. The experiment was stopped at this stage, and it was found on analysis

* See References at end of paper.
† Continuing the numbering of the 1921 report.

that there still remained 11·2 p.ct. of the nitrogen in the coke. It will be noticed that the ratio of ammoniacal nitrogen to free nitrogen is diminishing rapidly at temperatures above 800° C., although some ammonia is still formed and escapes decomposition at 1000° C.

The final balance-sheet has been calculated to the original coal.

NITROGEN BALANCE-SHEET AT 1000° C.
(500° C. coke, in hydrogen.)

Calculated to original coal—

	Per Cent.
Nitrogen given off in various forms during coking	21·6
Nitrogen obtained as ammonia	53·5
Nitrogen left in the coke	8·8
Nitrogen unaccounted for (free nitrogen)	16·1
	100·0

Thus in an atmosphere of hydrogen the 500° C. coke raised slowly in stages to 1000° C. yielded ammonia equivalent to 94·3 lbs. of ammonium sulphate per ton of original coal. This is the highest yield with hydrogen which we have seen recorded.

From these figures, it is seen that for producing ammonia instead of nitrogen in the primary period 500° C. to 800° C, an atmosphere of hydrogen is useful, and also that hydrogen. in addition to any preservative action in retarding the dissociation of ammonia once formed, has a specific action in that it is capable of liberating a portion of the nitrogen of the coke as ammonia which would otherwise be a stable constituent of the coke.

By treatment in hydrogen to 1000° C., the nitrogen left in the coke was reduced to 11·2 p.ct. of that originally present, and nitrogen was still leaving the coke, though very slowly, and mainly as free nitrogen with very little ammonia.

The nitrogen left in the 500° C. coke after treatment with hydrogen at different temperatures was: 800° C., 0·81 p.ct.; 900° C., 0·60 p.ct.; 1000° C., 0·41 p.ct.

DISSOCIATION OF AMMONIA.

It is of some interest at this stage to consider more specially the relative influence of nitrogen and hydrogen in preventing the dissociation of ammonia.

Considering (a) a mixture containing 99 p.ct. of nitrogen such as might be maintained by a stream of nitrogen, and (b) a corresponding mixture containing 99 p.ct. of hydrogen, the *equilibrium* quantities of ammonia in the two cases will be as 1 : 100 approximately (2).

Moreover this influence of nitrogen and hydrogen on the dissociation of ammonia in the presence of coke is being examined *experimentally* at Leeds by Mott and Hodsman (3), who have obtained the following figures under conditions comparable with those of our experiments.

Temperature.	Percentage Ammonia Dissociated.	
	In Hydrogen.	In Nitrogen.
750° C.	12	93
650° C.	*Nil*	43·5

Hydrogen is then much more effective in retarding the dissociation of ammonia than is nitrogen, apart from its specific action in forming ammonia with the nitrogen of the coke.

EXPERIMENTS WITH STEAM.

A parallel experiment was next carried out using steam throughout instead of hydrogen. As in our previous experiments, nitrogen was used as the carrier gas for the steam, being saturated at a definite temperature.

The experiments were conducted at 500° C., 600° C., 700° C., and 800° C. At the end only the ash of the coke remained. The coke was maintained at each successive temperature for 40 hours, being the same period as in the hydrogen experiment; and the results are graphed in fig. 13.

This experiment with steam gave a result which had not been obtained with hydrogen (and still less with nitrogen), in that the whole of the nitrogen of the coke within 1·7 p.ct. was obtained as ammonia.

An examination of the curve shows that there was not, as in the previous experiment with hydrogen, a falling-off in the liberation of ammonia when maintaining at each successive temperature, but a steady evolution. In the former case the curves are exponential in character, and in the latter case, after a rapid evolution of ammonia, linear, excepting in the 800° C. stage, where the coke was almost completely gasified.

EXPERIMENT 11.—*500° C. Coke Raised in Stages of 100° in Steam from 500° C. to 800° C.*

Weight of coke taken = 18·666 grms.
Per cent. nitrogen in coke = 1·87
Per cent. steam in steam-nitrogen mixture = 60·0 (saturated at 86° C.)
Rate of passage of the mixed gas = 12·5 litres per hour.

NITROGEN BALANCE-SHEET.

11*a*. Calculated to 500° C. coke—
Nitrogen obtained as ammonia—

	Per Cent.
1. 500° C. *Nil*	98·3
2. 600° C. 21·35	
3. 700° C. 51·29	
4. 800° C. 25·65	
Nitrogen in ash *Nil*	
*Nitrogen unaccounted for (free nitrogen) 1·7	
	100·0

11*b*. Calculated to original coal—

	Per Cent.
Nitrogen driven off in various forms during coking	21·6
Nitrogen obtained as ammonia	77·1
Nitrogen left in the ash	*Nil*
Nitrogen unaccounted for (free nitrogen)	1·3
	100·0

* NOTE.—At the end of the experiment the blocks and tubes were washed with hot water, and on distillation ammonia equivalent to 1·60 p.ct. of the total nitrogen of the coke was so obtained.

At each temperature stage in steam there is probably a double reaction taking place. The first is a decomposition of ammonia-yielding compounds in the coke such as accompanies a rise of temperature even in an inert atmosphere of nitrogen. The second is a reaction also liberating ammonia, but accompanied and probably conditioned by the gasification of the carbon of the coke. The first portion of the curve at each temperature superposes the results of these two reactions, but the second linear portion is due to the second reaction only.

It is interesting to note that during a considerable part of the process of gasification of the coke by steam the coke particles were unaltered in shape and size, although darker in colour. Gasification had been effected through the pores of the coke, leaving an outer layer apparently very little affected, with a skeleton structure below it. Finally this crumbled, and the powder burned completely to ash.

For comparison, the results when using nitrogen, hydrogen, and steam at 600° C. have been graphed together (fig. 14).

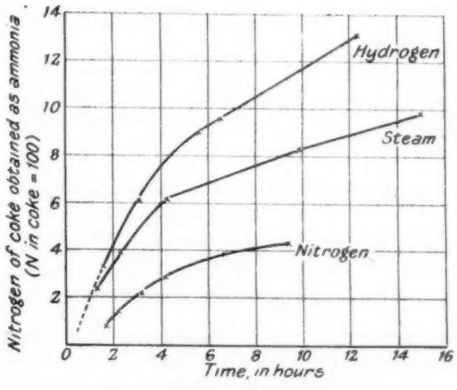


Fig. 14.—500° C. Coke at 600° C.

At this temperature in the initial stages hydrogen is more effective than steam, and nitrogen least of all. In later stages, however, the hydrogen curve is falling away while the steam curve is linear, and at approximately 40 hours a point is reached where the steam curve meets the hydrogen curve (fig. 13); and at this point 21 p.ct. of the total nitrogen of the coke is liberated as ammonia. If this comparison be made at 700° C. or higher temperatures, the rate of liberation of ammonia is much more rapid with steam than with hydrogen throughout the whole period.

The experiments with steam and a low-temperature coke had shown that the whole of the nitrogen could be obtained as ammonia. An experiment was made to determine whether a similar result could be attained with the high-temperature (1100° C.) coke. The coke was treated in turn at 800°, 900°, and 1000° C. in a current of nitrogen saturated with steam, with results given overleaf (Experiment 12).

The whole of the nitrogen of the coke (within the limits of experimental error) was obtained as ammonia.

A very large increase in the rate of ammonia evolution was obtained, as seen from the graph, on raising the temperature from 800° C. to 900° C.

EXPERIMENT 12.—1100° C. *Coke Raised in Stages of* 100° *in Steam from* 800° *to* 1000° C.

Weight of coke taken . . . . = 19·749 grms.
Percentage of nitrogen in coke . = 0·58
Percentage of steam in steam-nitrogen mixture . . . . . = 63
Rate of passage of the mixed gas . = 13·5 litres per hour.

NITROGEN BALANCE-SHEET.

12. Calculated to 1100° C. coke—
Nitrogen obtained as ammonia—

	Per Cent.
1. 800° C.	1·36
2. 900° C.	95·40 — 97·3
3. 1000° C.	0·59
Nitrogen in ash	*Nil*
Nitrogen unaccounted for (free nitrogen)	2·7
	100·0

After a period of 70 hours at 900° C. the residue was examined. It was found to be powdery, but not completely ashed. The temperature was raised to 1000° C., and kept there for 11 hours, during which period the ammonia evolution ceased. The ash remaining was of a greyish hue.

The slowness of liberation of ammonia from the hard coke is no doubt bound up with the slowness of gasification of the carbon, but this subject is receiving separate treatment.

SUMMARY OF NITROGEN RESULTS.

The results so far obtained may be briefly summarized thus: The behaviour of the nitrogen in coal and coke has been examined under the influence of heat, in an inert atmosphere (nitrogen), in hydrogen, and in steam.

Our experiments were made with: (*a*) A soft coke, 500° C.; (*b*) a medium coke, 800° C.; (*c*) a hard coke, 1100° C.

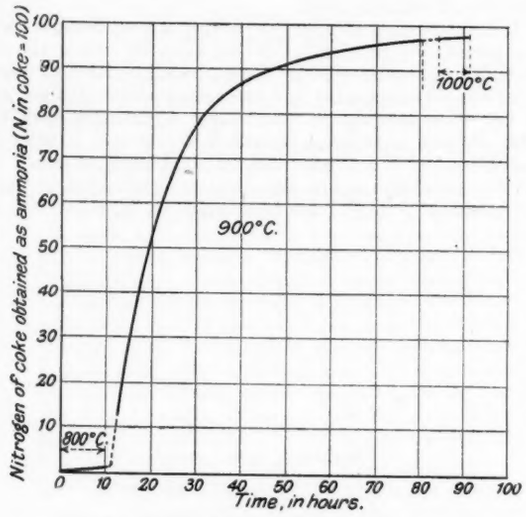


Fig. 15.—1100° C. Coke (using Steam).

1.—By heating the 500° C. coke in an inert atmosphere, nitrogen was liberated; but up to 800° C., only one-third of this nitrogen was obtained as ammonia, the rest being free nitrogen. No appreciable quantity of ammonia was obtained above 700° C., although above this temperature the coke continued to lose nitrogen.

2.—At a temperature of 800° C. with the 500° C. coke, an atmosphere of hydrogen, in addition to any preservative action in retarding the dissociation of ammonia once formed, exerted a specific action in liberating a portion of the nitrogen as ammonia which would otherwise have remained in the coke. By prolonged treatment with hydrogen up to 1000° C. in stages, 68·2 p.ct. of the nitrogen of the coke was obtained as ammonia. With the 800° C. coke, the attack of hydrogen was feebler and the ammonia recoverable smaller. With the 1100° C. coke, the hydrogen had no power of attack up to 1000° C.

3.—By gasification of the coke with steam the whole of the nitrogen was obtained as ammonia, the liberation of ammonia being much more rapid (above 600° C.) than with hydrogen. The liberation of ammonia by steam from hard coke was much slower than from soft coke, and very much slower at 800° than at 900° C.

II. THE LIBERATION OF SULPHUR FROM COAL AND COKE AS SULPHURETTED HYDROGEN.

The experiments to be described under this head were made primarily on the liberation of nitrogen from coal and coke as ammonia (*vide* 1921 Report, Trans. Inst. Gas Eng.); but parallel determinations of sulphuretted hydrogen were made, and the results are collated here.

Coal was coked at three temperatures, 500°, 800°, and 1100° C., so preparing soft, medium, and hard cokes. The action of hydrogen on these cokes was determined and compared with that of an inactive gas—viz., nitrogen.

Details of the experiments have been given; and for purposes of comparison the same numbering will be retained. (See 1921 Report.)

Analysis of the Yorkshire Bituminous Coal (Warrenhouse) Used.

PROXIMATE ANALYSIS
by the Method of the American Chemical Society.

	P.Ct.
Moisture (air-dried sample)	5·38
Volatile matter	33·96
Fixed carbon	56·00
Ash	4·66
	100·00

ULTIMATE ANALYSIS.

	P.Ct.		Calculated to Dry Ash-Free Coal. P.Ct.
Carbon	73·26	..	81·44
Hydrogen	5·06	..	5·62
Nitrogen	1·67	..	1·86
Sulphur	1·75	..	1·94
Oxygen	8·22	..	9·14
Ash	4·66	..	..
Moisture	5·38	..	..
	100·00		100·00

ANALYSIS OF ASH.

	Per Cent.
Silica (SiO_2)	25·06
Alumina (Al_2O_3)	33·46
Iron oxide (Fe_2O_3)	10·06
Lime (CaO)	13·06
Magnesia (MgO)	Traces
Sulphuric oxide (SO_3)	12·91
Alkalies (K_2O, Na_2O)	5·08
	99·63

Phosphoric oxide and titanium oxide were not determined.

SULPHUR.

	Per Cent.
Sulphur in original coal	1·75
Sulphur in 500° C. coke	1·41
Sulphur in 800° C. coke	1·40
Sulphur in 1100° C. coke	1·30

Taking the sulphur in the coal as 100, that in the 500° and 800° C. cokes was 56·4 and 50·1, respectively.

EXPERIMENT 1.—500° C. *Coke, using Nitrogen Gas.*

Temperature.	Sulphur obtained as H_2S in Per Cent. of Total Sulphur of Coke.
600° C.	0·5
800° C.	0·25
1000° C.	0·8
	1·55

EXPERIMENT 3.—800° C. *Coke, using Nitrogen Gas.*

Temperature.	Sulphur obtained as H_2S in Per Cent. of Total Sulphur of Coke.
600° C.	0·31
800° C.	0·13
1000° C.	0·03
	0·47

SULPHUR BALANCE-SHEET.
(For 800° C. coke, using nitrogen gas.)

3*a*. Calculated to coke—

	Per Cent.
Sulphur obtained as H_2S	0·5
Sulphur left in the coke	97·6
Sulphur unaccounted for	1·9
	100·0

3*b*. Calculated to coal—

	Per Cent.
Sulphur driven off during coking =	49·9
Sulphur obtained as H_2S on passage of N_2 =	0·3
Sulphur left in coke =	48·9
Sulphur unaccounted for =	0·9
	100·0

EXPERIMENT 4.—800° C. *Coke, using Hydrogen Gas.*
Sulphur in original coke = 1·40 p.ct.

Temperature.	Sulphur obtained as H_2S in Per Cent. of Total Sulphur of Coke.
600° C.	1·1
800° C.	23·4
1000° C.	21·7
	46·2

SULPHUR BALANCE-SHEET.
(For 800° C. coke, using hydrogen gas.)

4*a*. Calculated to coke—

	Per Cent.
Sulphur obtained as H_2S	46·2
Sulphur left in the coke	53·2
Sulphur unaccounted for	0·6
	100·0

4*b*. Calculated to original coal—

	Per Cent.
Sulphur driven off during coking =	49·9
Sulphur obtained as H_2S by passage of hydrogen =	23·1
Sulphur left in coke =	26·7
Sulphur unaccounted for =	0·3
	100·0

The results are graphed in fig. 16.

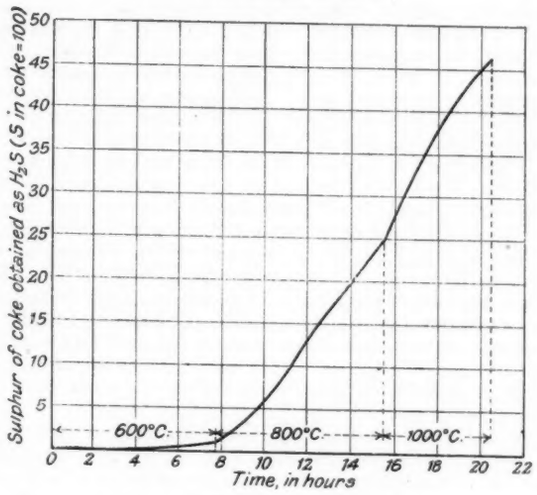


Fig. 16.—800° C. Coke (using Hydrogen).

EXPERIMENT 5.—1100° *C. Coke, using Hydrogen Gas.*

Sulphur in coke = 1·30 p.ct.

Temperature.	Sulphur obtained as H_2S in Per Cent. of Total Sulphur of Coke.
600° C.	1·8
800° C.	11·4
1000° C.	12·1
	25·3

SULPHUR BALANCE-SHEET (5).
Calculated to coke.

	Per Cent.
Sulphur as sulphuretted hydrogen	25·3
Sulphur left in coke	76·5
	101·8

These experiments with hydrogen were not carried to completion as indicated by the shape of the graph (figs. 16 and 17). From these it is seen that hydrogen liberated much of the sulphur as sulphuretted hydrogen from coke.

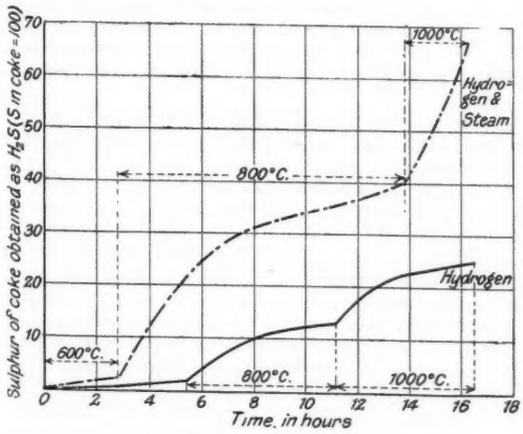


Fig. 17.—1100° C. Coke.

In an atmosphere of nitrogen, however, up to 1000° C. very little sulphuretted hydrogen was obtained, and very little sulphur was eliminated from the coke in any form.

Two differences between the liberation of sulphuretted hydrogen and ammonia by hydrogen are at once noticeable.

(1) After passing hydrogen, the sulphur as sulphuretted hydrogen and that left in the coke together equalled, within the limits of experimental error, the sulphur in the coke before passing hydrogen. There was no loss by dissociation of sulphuretted hydrogen corresponding with that of ammonia. A comparison of the dissociation figures at equilibrium for sulphuretted hydrogen and ammonia will explain this difference.

SULPHURETTED HYDROGEN (4).

t° C.	750°.	830°.	945°.	1055°.	1132°.
Per cent. dissociated	5·5	8·7	15·6	24·7	30·7

AMMONIA (5).

t° C.	500°.	700°.	900°.
Per cent. dissociated	99·87	99·98	99·99

(2) Hydrogen at 800° C. attacked the sulphur compounds in the hard coke prepared at 1100° C., but not the nitrogen compounds.

EXPERIMENT 6.—1100° *C. Coke, using Steam and Hydrogen (together).*

Sulphur in coke = 1·30 p.ct.

Temperature.	Sulphur obtained as H_2S in Per Cent. of Total Sulphur of Coke.
600° C.	2·3
800° C.	38·2
1000° C.	26·6
	67·1

Thus, using steam along with the hydrogen, two-thirds of the sulphur was eliminated from the coke as against a quarter using hydrogen alone. The extensive attack at 800° C. on the hard coke is again noticeable.

EXPERIMENT 7.—500° *C. Coke at* 800° *C.*

In this experiment the successive action of nitrogen, hydrogen, and steam was determined at 800° C. From fig. 12 it will be seen that in the nitrogen stage only 1 p.ct. of the total sulphur of the coke was liberated as sulphuretted hydrogen. This is in agreement with the previous results. In the hydrogen stage a further 51·8 p.ct. was obtained. From the nature of the curve it would appear that the reaction of the hydrogen with the coke liberating sulphuretted hydrogen had then practically ceased. On passage of steam a further quantity of sulphuretted hydrogen was evolved, making a total of 93 p.ct. of the original sulphur of the coke obtained as sulphuretted hydrogen.

SULPHUR BALANCE-SHEET.

Calculated at 500° C. coke—
Sulphur obtained as sulphuretted hydrogen—

	Per Cent.	
1. Nitrogen stage	1·0	
2. Hydrogen stage	51·8	93·0
3. Steam stage	40·2	
Sulphur remaining in ash		1·3
Sulphur unaccounted for		5·7
		100·0

EXPERIMENT 8.—*Treatment of* 500° *C. Coke at* 800° *C. with Nitrogen and Steam Successively.*

In this experiment only 53·7 p.ct. of the total sulphur was accounted for as sulphuretted hydrogen (only 1·0 p.ct. in the nitrogen stage) and 0·8 p.ct. in the ash, but the sulphuric acid washers were quite milky, presumably due to the presence of sulphur from the interaction of sulphuretted hydrogen and sulphur dioxide. In subsequent experiments using steam, this same phenomenon was observed, and the same faulty balance-sheet resulted, indicating reactions other than the production of sulphuretted hydrogen.

EXPERIMENT 9.—500° *C. Coke in a Current of Nitrogen Gas at* 500°, 600°, 700°, *and* 800° *C.*

The liberation of sulphuretted hydrogen by nitrogen was again very small.

Sulphur as sulphuretted hydrogen (calculated on S in coke).

	Per Cent.	
1. 600° C.	0·3	
2. 700° C.	0·2	0·8
3. 800° C.	0·3	

A repeat experiment gave 0·9 p.ct.

EXPERIMENT 10.—500° *C. Coke Raised in Temperature Stages to* 1000° *C. in Hydrogen.*

Sulphur obtained as sulphuretted hydrogen.

	Per Cent.	
1. 500° C.	0·4	
2. 600° C.	37·1	
3. 700° C.	18·6	
4. 800° C.	7·3	93·8
5. 900° C.	24·8	
6. 1000° C.	5·6	

The results are graphed in fig. 18.

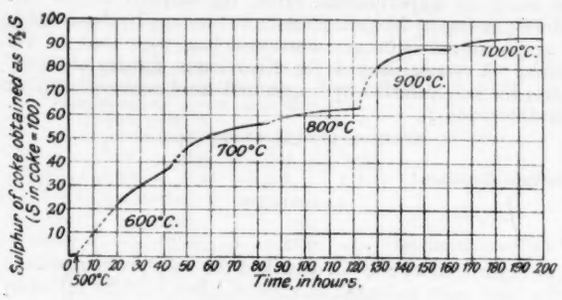


Fig. 18.—500° C. Coke (In Hydrogen).

Up to 800° C. the evolution of sulphuretted hydrogen was steady, but at 800° C. fell away as in Experiment 7. 63·4 p.ct. was liberated up to this point as sulphuretted hydrogen, as against 52·8 p.ct. in experiment 7. On increasing the temperature, however, to 900° C., a considerable further evolution of sulphuretted hydrogen occurred; and up to 1000° C. a total of 93·8 p.ct. of the total sulphur was obtained as sulphuretted hydrogen. It is therefore probable that treatment of this coke with hydrogen removes practically all the sulphur as sulphuretted hydrogen when a long time is allowed and the temperature is gradually raised to 1000° C. There is a critical point about 900° C. which may correspond with the decomposition of some sulphur compound requiring that temperature for its breakdown.

EXPERIMENT 11.—500° *C. Coke in Temperature Stages in Steam.*

In this experiment, as in previous steam experiments, the total sulphur was not accounted for. 66·4 p.ct. of the sulphur was obtained as sulphuretted hydrogen, and only traces left in the ash.

The rate of sulphuretted hydrogen formation is slower than with hydrogen up to 800° C., but that of sulphur elimination from the coke probably about the same.

EXPERIMENT 12.—1100° *C. Coke, using Nitrogen and Steam.*

In this experiment 60·6 p.ct. of the sulphur was obtained as sulphuretted hydrogen—24·2 p.ct. at 800° C., 36·1 p.ct. at 900° C., and 0·3 p.ct. at 1000° C.—but practically the whole was eliminated from the coke. It is noticeable that the liberation of sulphuretted hydrogen was quite vigorous even at 800° C., when the attack on the carbon and the nitrogen compounds would be very slow.

RESULTS OBTAINED BY OTHER WORKERS.

Sulphur is stated to occur in coal mainly as pyrites or marcasite, calcium sulphate, and organic sulphur. The behaviour of the sulphur in coal on coking has been investigated by Powell and Parr (6, 7), who give the following reactions as occurring:

1. Complete decomposition of pyrites and marcasite to ferrous sulphide, pyrrhotite, and sulphuretted hydrogen. The reaction begins at 300° C., is complete at 600° C., and reaches a maximum between 400° and 500° C.
2. Reduction of sulphates to sulphides—complete at 500° C.
3. Decomposition of organic sulphur to form sulphuretted hydrogen. One-quarter to one-third of the organic sulphur is affected in the primary decomposition, but bye-product gas increases this decomposition to one-half.
4. A decomposition of a small part of the organic sulphur to form volatile organic sulphur compounds which go into the tar. This occurs at an early stage of the coking process.
5. Disappearance of a portion of the ferrous sulphide and pyrrhotite—the sulphur entering into combination with the carbon. (This occurs at 500° C. and higher temperatures.) The organic sulphur undergoes a change in character between 400° and 500° C.

Our experiments have shown that up to 1000° C. in a current of nitrogen the sulphur of the 500° C. coke is not appreciably diminished (only 1—2 p.ct. removed), but that if a current of hydrogen is used the sulphur can be reduced to a very small proportion of that originally present, or even eliminated.

Thus in Experiment 7 at the end of the hydrogen stage (Stage II.) at 800° C. 52·8 p.ct. of the sulphur of the coke was obtained as sulphuretted hydrogen after 130 hours' treatment. In Experiment 10 made in temperature stages with the 500° C. coke to 800° C. in a current of hydrogen, a slightly larger amount of sulphur was obtained as sulphuretted hydrogen—viz., 63·4 p.ct. When, however, the temperature was raised to 900° C., a rapid evolution of sulphuretted hydrogen occurred, and up to 1000° C. a total of 93·8 p.ct. of the sulphur of the coke was obtained as sulphuretted hydrogen.

Powell (7) reduced the sulphur in coke from 1·21 to 0·11 p.ct. by the use of hydrogen at 1000° C. This confirms our own results. He found that the evolution of sulphuretted hydrogen ceased if the temperature was lowered to 500° C.

Recent work by Wibaut (8) has shown that a carbon-sulphur compound prepared from sugar or wood charcoal and sulphur was stable at 1000° C. in vacuo, but would give up one-third of its sulphur as sulphuretted hydrogen when heated from 550 to 750° C. in a stream of hydrogen. In another experiment, 75 p.ct. of the sulphur was evolved as sulphuretted hydrogen at 750° C. By heating to 800° C. in hydrogen for a longer period the whole of the sulphur was removed.

Powell quotes from Roscoe and Schorlemmer (9) the statement that hydrogen does not react with hot ferrous sulphide; and to explain the removal of the sulphur of the coke by hydrogen, he supposes that a combination takes place between the sulphur of the ferrous sulphide and the carbon of the coke, giving a carbon sulphur compound, and that this carbon sulphur compound is subsequently attacked by hydrogen—in other words, that the sulphur of the ferrous sulphide must unite with carbon in order that the formation of sulphuretted hydrogen may occur.

In order to examine the statement of the text-books (9, 10) that hydrogen has no action on ferrous sulphide, a sample of commercial fused ferrous sulphide which contained some free iron was heated in a current of hydrogen in an electric furnace. Sulphuretted hydrogen began to come off at 680°, and as the temperature rose was evolved more freely until 70 p.ct. of the total sulphur had been expelled at 1000° C. while sulphuretted hydrogen was still coming off. The text-book statement and theories based upon it seem to require further examination.

SUMMARY OF SULPHUR RESULTS.

Our own work herein described on this subject may be summarized thus:

The liberation of sulphuretted hydrogen from three cokes prepared in the laboratory at 500°, 800°, and 1100° C. has been studied in the course of experiments made primarily for the study of the liberation of ammonia.

The coal used was Yorkshire (Warrenhouse) bituminous coal; and it is believed that the nature of the coal probably affects the sulphuretted hydrogen results more than the ammonia results, because of the influence of sulphur combined with such inorganic elements as iron and calcium.

Of 100 parts of sulphur present in the coal, the quantities occurring in the 500° C. and 800° C. cokes were 56·4, 50·1.

[*Cf.*—Of 100 parts of nitrogen present in the coal, the quantities occurring in the 500° C. and 800° C. cokes were 78·4, 50·3.]

On heating the cokes in nitrogen, very little sulphuretted hydrogen was evolved up to 1000° C., and very little sulphur was lost from the cokes.

On heating the 500° C. coke in hydrogen, sulphuretted hydrogen was evolved steadily up to 800° C., when it fell away in quantity. Although the heating in hydrogen was prolonged (40 hours at each temperature), sulphuretted hydrogen was still coming off steadily at each temperature, when the ammonia evolution had nearly ceased. At 900° C. the evolution of sulphuretted hydrogen quickened again in a manner which suggested attack on some compound previously resistant. When treatment ceased at 1000° C., 93·8 p.ct. of the sulphur of the coke had been obtained as sulphuretted hydrogen. No effect corresponding with the dissociation of ammonia was noticed. On heating in steam the loss of sulphur was rapid, but probably not more rapid than with hydrogen up to 800° C. Completion of decomposition could, however, be secured in steam at that temperature when the attack of hydrogen had become negligible. Probably the sulphur compound was attacked by steam at 800° C., which required a rise of temperature to 900° C. if hydrogen was employed. With both hydrogen and steam, and particularly with a mixture of the two, the sulphur in the 1100° C. coke

was attacked vigorously at lower temperatures, such as 800° C., at which the nitrogen compounds (and the carbon) were little affected.

References— NITROGEN.

(1) 1921 Report, Gas Research Fellowship, Trans. Inst. Gas Eng., pp. 543-572.
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(3) Mott and Hodsman. Private communication.

SULPHUR.

(4) Preuner and Schupp. Zeit. physik. Chem. 68 (1909), p. 157.
(5) Haber. Zeit. Elektrochem. 20 (1914), p. 600.
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(7) Powell. Jour. Ind. Eng. Chem. 12 (1920), pp. 1069-1077; Jour. Ind. Eng. Chem. 13 (1921), p. 33.
(8) Wibaut. Rec. Trav. Chem. 41 (1922), p. 153.
(9) Roscoe and Schorlemmer. Treatise on Chemistry, 1907, Vol. II., p. 1208.
(10) Friend. Text-book of Inorganic Chemistry (1921), Vol. IX., Pt. II., p. 132.

Prof. J. W. COBB, in presenting the report, said: In the paper in which Dr. Monkhouse and I last year reported results, we expressed our intention of carrying on the study of the liberation of nitrogen from coal and coke as ammonia, and also of extending that study to the conditions of liberation of sulphur—the sulphur being liberated as sulphuretted hydrogen. The paper that we now present to you contains what we hope is a further elucidation of the matters in question. In one of our experiments, which I may recall, detailed in the last report, we showed that, starting with a low-temperature coke, from which the first flush of ammonia had been driven away in the carbonization, it was possible to obtain a certain amount of additional ammonia from it by simply heating at 800° C. in a current of nitrogen; then more ammonia by supplementary treatment with hydrogen applied when the nitrogen had ceased to be of any effect; and still more ammonia by a treatment with steam when the action of hydrogen had become almost *nil*. The total ammonia obtained by the successive treatments in three stages had been equivalent to some 80 p.ct. of the nitrogen originally present in the coke. We have now extended that work by seeing what liberation of nitrogen as ammonia could be brought about if the temperature was raised gradually by stages of 100° C. up to 1000° C., so minimizing any dissociation of ammonia that might occur—giving, that is, any ammonia that might be formed an opportunity to escape as soon as it was formed, not carrying it to any higher temperature which would assist its dissociation. Parallel experiments for this purpose were made with nitrogen, hydrogen, and steam.

I would rather leave to my colleague, the Research Fellow, Dr. Monkhouse, the presentation of the results; but I may point out that, if the treatment is sufficiently prolonged, hydrogen has a remarkable power of liberating ammonia from a soft coke; 68·2 p.ct. of the nitrogen having been obtained in one experiment as ammonia. You will remember that ordinary gas-works practice only gives about 15 to 20 p.ct. But this does not happen with a hard coke, which the hydrogen seems powerless to attack, and even with soft coke the ammonia comes away with extreme slowness, and after a time; so that the yield obtained in our experiments could not be realized in ordinary practice. Still, we wanted to know what the position was, and what could be done when the hydrogen was given its chance to work, as far as it could possibly work, in the direction of liberating ammonia. When we came to steam, however, we found the conditions were different, because the whole of the nitrogen can be obtained as ammonia even from a hard coke, though the liberation of ammonia from hard coke was much slower than from soft coke, and very much slower at 800° than at 900°. The formation and the recovery of ammonia, at any rate in all later stages of gasification, depend apparently upon gasifying the accompanying carbon; and this is done more quickly with soft than with hard coke.

Although our experiments as we made them were primarily for the study of the liberation of ammonia, there was a washer in the train of apparatus used for the absorption of sulphuretted hydrogen in all the experiments; and the results obtained are quite interesting, and are reported. I may say that, roughly speaking, what is demonstrated is that, taking a soft coke which contains about half the sulphur originally present in the coal, very little sulphuretted hydrogen was obtained by further heating so long as that was done in an inert atmosphere (nitrogen), and very little sulphur was lost. When hydrogen was used instead of nitrogen, the behaviour was quite different. On heating in this gas, sulphuretted hydrogen came off steadily up to 800° C. Then there was a check; but at 900° the evolution quickened again; and on prolonged treatment up to 1000°, 94 p.ct. of the sulphur of the coke came away as sulphuretted hydrogen. There were two main differences between the liberation of nitrogen and that of sulphur. In the first place, there was little loss of sulphuretted hydrogen, when it was once formed, by dissociation. Practically all the sulphur could be accounted for, either as sulphur left in the coke residues or as sulphuretted hydrogen. Another difference in behaviour was that sulphuretted hydrogen came off in quantity from even a hard metallurgical coke, when it was treated in hydrogen at a medium temperature. The changes occurring in the coking did not have the same sort of effect with the sulphur as with the nitrogen compounds. These latter—the nitrogen compounds—in a hard coke could not be attacked to any appreciable extent by treatment with hydrogen at a lower temperature; but the sulphur compounds, even in a hard metallurgical coke could be quite readily attacked by subjecting the coke to treatment with hydrogen at even a medium temperature. There is a fundamental difference there between the nitrogen and the sulphur compounds formed and their behaviour.

This report, as we have presented it, may seem at first sight to be of more theoretical than practical interest; but I should not like that impression to be too deep in your minds. In view of such possible changes in the gas industry as may be brought about by the extended gasification of fixed carbon from coke by steaming in gas-retorts, water-gas manufacture, or complete gasification with air and steam or with air and oxygen, or by some method not yet even suggested, we believe that the study of what happened to the nitrogen and sulphur compounds of the coke under various conditions will be both interesting and useful.

Dr. MONKHOUSE then gave a summary of the report.

Discussion.

The PRESIDENT: I move the adoption of the report.

Mr. J. P. LEATHER (Burnley): I wish to second it. There is just one thought I should like to voice, after reading the report through. Does it mean that steaming, for instance, in vertical retorts is likely to produce more sulphuretted hydrogen in the gas? I take it that the action of hydrogen and steam on the sulphur in the coke takes place more readily than the action on the nitrogen, and if we increase the quantity of ammonia in the gas by steaming, we shall increase the quantity of sulphuretted hydrogen also by steaming. I do not know that there is any great objection to this, for when sulphur is valuable we can purify our gas without very great expense; but if there is more sulphuretted hydrogen in the gas, we shall require rather larger purifiers. I would like to ask whether the experimenters think that will be the case—that we shall have more sulphuretted hydrogen in the gas from steaming in vertical retorts. I must express my thanks to those who are conducting these researches.

The PRESIDENT: I think perhaps Dr. Monkhouse might indicate whether, when the gases are mixed, such as we have in ordinary retort-house work, the same chemical reactions would take place.

Mr. WILLIAM J. SMITH (Bolton): I understand that the dissociation of the ammonia takes place round about 800° C. The Professor stated that when he had got up to 900° C. there was further ammonia evolved at a greater rate. I take it there is some reason for this. I just wondered whether there was a possibility of getting ammonia back after dissociation, or if you abide by the constituents of ammonia in the gas.

Mr. SAMUEL GLOVER: The answer to some of these questions would be affected by the condition and size of the coke experimented upon; and perhaps in answering the other questions, the authors would tell us the condition (I mean the physical condition) of the coke used in the experiments, and also the effect on the coke of the experiments—that is other than those of steaming—which reduced the coke to ash. The effect on the coke, and the quality and size of the coke used in these experiments, would have their influence in the answers to the questions as to what was done in an ordinary retort if extraordinary sizes of coke—I mean broken-down coke or coke of special sizes and shape—were used; whether that would not have considerable effect upon the time factor, which seems to be very important, as stated in these graphs.

Dr. MONKHOUSE: As to the question of the removal of sulphur from the coal with steam, in steaming in vertical retorts you will get more sulphuretted hydrogen in your gas. In our experiments with steam we were not able to obtain a balance-sheet, because in these experiments we got sulphur formed in the first washer, probably due to the interaction of sulphur dioxide with sulphuretted hydrogen. With regard to the question of the dissociation of ammonia at temperatures such as 900° C., the great reason why we do not get all our ammonia dissociated at that temperature is that the time of contact is so small that you have not time to get equilibrium. The figures given show that practically the whole of the ammonia will dissociate at 900° C. if equilibrium conditions are attained; but the ammonia is swept away before such a condition is attained. With regard to the size of the coke, in our experiments it was ¼ to ⅛ in. mesh; and in the hydrogen experiments no alteration was observed in the size of the coke. In the steam experiments a curious phenomenon was observed. The burning of the coke with the steam seemed to take place through the pores of the coke. On removing the coke in the course of experiment, it was found that the coke had practically the same size of particle, but was rather darker in colour. Subsequently it fell to pieces, and burned to ash. The process of gasification seemed to take place mainly through the pores of the coke. This matter is being investigated. The time factor we tried to make somewhat the same as in ordinary retort practice, and the concentrations of ammonia were kept low.

The PRESIDENT: Dr. Monkhouse is just vacating the Fellowship; and I am sure we congratulate him on the very valuable work he has done. (Hear, hear.)

The report was adopted.

REPORT OF LIFE OF GAS-METERS JOINT COMMITTEE.

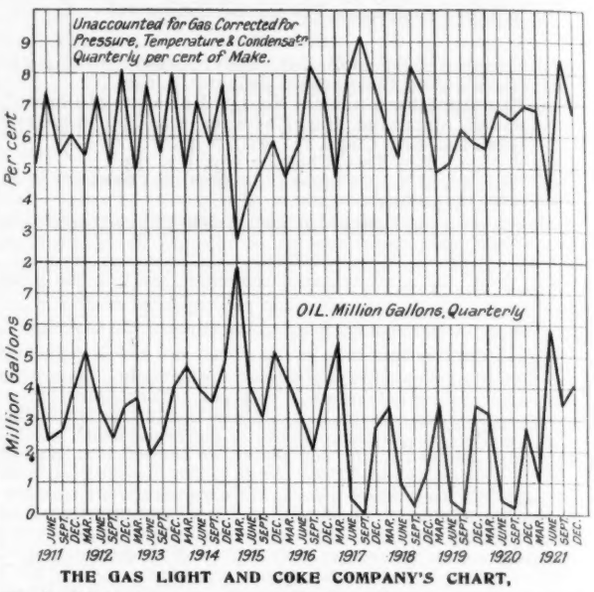
Section A.—INTERNAL CORROSION AND MODERN GAS PRACTICE.

The question is sometimes asked: "What are the changes in gas practice which have brought about more rapid deterioration of meters, with the attendant evils of internal corrosion in mains and services, and also in gas plant?" It may therefore be useful to summarize in this report the five principal changes which have occurred, with their effects, and the suggested remedies or palliatives.

(1) *The Change from Lime to Oxide in Purification.*—When lime was used, it would take out CO_2 and also HCN (hydrocyanic acid) from the gas; but with oxide purification a large proportion of these remain. There is also some increase in the CS_2 (carbon bisulphide) allowed to go forward, which, by interaction with any possible ammonia that may get through, produces the most destructive salts. Although the change from lime to oxide dates back a considerable number of years, its detrimental effect has been aggravated more recently by the impoverishment of the gas in respect to hydrocarbons, which shall be referred to presently. The principal remedy lies in the suggested removal of hydrocyanic acid by a simple method, such as the chalk process at present under trial, a description of which is given under section (*b*). No suggestion is made for removal or diminution of carbon dioxide content; for this is a weak acid detrimental only in presence of the condensed moisture to be referred to later. Sulphur compounds (as CS_2) are harmful as corrosive agents only in conjunction with ammonia; and it should not be necessary to draw any further attention to the extreme importance of efficiency in the ammonia washing plant.

(2) *The destruction (or "cracking") of the hydrocarbons* in the gas has greatly aggravated the effect of the impurities allowed to go forward by the change to oxide purification. High temperature carbonization, giving increased make per ton, has tended to dissipate those constituents which have been the natural lubricants and preservatives of the distribution system. No royal remedy for that can be suggested without interference with the inevitable tendency of modern gas practice; but it does require that greater attention must be paid to the removal of certain impurities in the gas, particularly the HCN whose quantity is actually increased. It is, however, of great interest to find that the absence of rich hydrocarbons in coal gas can be made up for by the carburetting of water gas, as proved by the experience of The Gas Light and Coke Company. During the coal strike of 1915 the increased use of oil gas was accompanied by marked diminution in the percentage of unaccounted-for gas, which could only be explained as the effect of the oily constituents of the carburetted water gas on the behaviour of meters. Precisely the same cause and effect appear in the returns for the period of the coal strike in 1921 (see accompanying chart).

(3) *Aqueous Vapour in the Gas* has been given much greater freedom of action by the absence of oily constituents. It may act either as a vehicle for corrosive salts, or as a simple aid to corrosion in conjunction with such agents as oxygen and carbon dioxide. Greater attention should therefore be given, both on works and district, to the subject of temperature and aqueous condensation. In order to avoid the deposition of moisture in mains, services, and meters, gas should, strictly speaking, be sent out under-saturated—that is, with its dewpoint at a temperature lower than the temperature it is likely to acquire during passage through the mains. It is, however, generally assumed that gas leaves the works saturated with aqueous vapour arising from the station meter and gasholder, however efficient may be the condensing plant. Suggestion is made that a film of heavy oil on the surface of the waters in meter and holder would lessen evaporation as well as help to preserve the plant itself. (If water-gas tar oil be used for this purpose, it should first be dehydrated, and then the lighter portions distilled off.) The effect of temperature (relative to the dewpoint) on aqueous condensation is similar to its effect on the deposition of naphthalene, and is worth a good deal more attention than it usually receives. Paraffin vaporization is a remedy or palliative prescribed both for corrosion and naphthalene troubles; but it has been established that a gas saturated with water will not hold much paraffin vapour.


Unaccounted for Gas Corrected for Pressure, Temperature & Condensate Quarterly per cent of Make.
Per cent
OIL. Million Gallons, Quarterly
Million Gallons
JUNE SEPT. DEC. MAR.
1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921

THE GAS LIGHT AND COKE COMPANY'S CHART,
Showing Diminution of Unaccounted-for Gas with increased Carburation.

The consideration of *temperature and condensation* applies at least equally to the location of consumers' meters. Exposed positions, draughty places, damp and cold cellars, where it has so often in the past been the custom to place the gas-meter, are exactly the places where the meter should *not* be. Or, if there be no protected place available, it is advisable to wrap the meter in some warm material, the expense of which would probably be trifling in comparison with the cost of repairs and loss of revenue through slow registration.

In each of the three last reports of the Committee, reference has been made to high-pressure distribution as offering the best means for condensation of the gas before transmission. It is vital that the extra condensation due to compression should not be left to take place in the mains, for that has doubtless brought about the formation of the oxide dust found in services, governors, and meters, which originated this investigation. A promise was made to republish a table showing the quantity of water contained in the gas at various temperatures and pressures, corrected to standard conditions. From this table, which is appended, it will be seen that saturated gas at atmospheric pressure and 50° Fahr. contains 58 gallons of water per million cubic feet. If this be compressed to 9 lbs. per square inch and then cooled to the same temperature (50° Fahr.) the aqueous content will be reduced to 36 gallons. Then if the pressure be lowered to 5 lbs. per square inch for transmission, the gas will be capable of holding 43 gallons, but will only contain 36. Thus it can pass into the mains at the 5 lbs. pressure without further condensation, unless the temperature in the mains falls to 45° Fahr., where the 36 gallon dewpoint is reached. But in the meantime the pressure during transmission may gradually diminish along the line of main, and still further lower the dewpoint. This is merely an example of how the table can be used.

(4) *Oxygen in the Gas* arising from the introduction of air for revivification of oxide has added another simple agent of corrosion. Concurrently there has been the desire to relieve coal-gas retorts from pressure for improved carbonization results, and where there are not exact means of control, this may often involve the inclusion of more air than is required for purification, with possible addition of furnace gasses. The right proportion of air must depend upon the amount of sulphur in the coal and the quality of oxide employed, but should seldom exceed 2½ p.ct. The action of oxygen on metals as an agent of corrosion in presence of moisture is well enough known, but on the leathers of dry meters its action is not sufficiently realized. It can be proved by the fact that when a meter is taken

Aqueous Vapour in Saturated Gas at various Temperatures and Pressures expressed in Gallons of Water per Million Cubic Feet of Free Gas corrected to 60° Fahr. and 30" Mercury.

Temp. Fahr.	Absolute Temp.	Pressure of Aqueous Vapour Inches Mercury	Gauge Pressure in lbs. per sq. inch. 0	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	35	40	45	50
			Absolute Pressure in inches of mercury.																			
			29·92	31·96	33·99	36·03	38·06	40·10	42·14	44 17	46·21	48·24	50·28	54·35	60·46	70·64	80·82	91·00	101·18	111·36	121·54	131·72
32°	492	0·18	29	27	25	24	23	22	21	20	19	18	17	16	14	12	10½	9½	8½	7½	7	6½
35°	495	0·20	32	30	28	27	25	24	23	22	21	20	19	18	16	13½	12	10½	9½	8½	8	7½
40°	500	0·25	40	38	35	33	32	30	29	27	26	25	24	22	20	17	15	13	12	11	10	9
45°	505	0 30	48	45	42	40	38	36	34	33	31	30	29	27	24	20	18	16	14	13	12	11
50°	510	0·36	58	54	51	48	46	43	41	39	37	36	34	32	29	24	21	19	17	15½	14	13
55°	515	0·43	70	65	61	58	55	52	49	47	45	43	41	38	34	29	26	23	20	18½	17	15½
60°	520	0·52	84	79	74	70	66	63	60	57	54	52	50	46	42	35	31	27	25	22	20	19
62°	522	0·56	91	85	80	75	71	68	64	61	59	56	54	50	45	38	33	30	27	24	22	20
65°	525	0·62	101	95	88	84	79	75	71	68	65	62	60	55	50	42	37	33	30	27	25	23
70°	530	0·73	119	112	105	99	93	89	84	80	77	73	70	65	58	50	43	39	35	31	29	27
75°	535	0·87	143	134	125	118	112	106	101	96	92	88	84	78	70	60	52	46	42	38	35	32
80°	540	1·02	169	157	148	139	131	125	118	113	108	103	99	91	82	70	61	54	49	44	40	37
85°	545	1·20	200	186	175	165	155	147	140	133	127	122	117	108	97	83	72	64	57	52	48	44
90°	550	1·41	236	220	207	194	184	174	165	157	150	144	138	127	114	97	85	75	67	61	56	52
95°	555	1·65	279	260	244	229	216	205	195	185	177	169	162	150	134	114	100	88	79	72	66	61
100°	560	1·92	327	306	286	269	254	240	228	217	207	198	190	175	157	133	116	103	92	84	77	71
212°	672	29·92																				

for repair, after being subject to gas, the diaphragms will rapidly deteriorate when exposed to the air; hence it is vital that the inlet and outlet connections of all dry meters should be corked immediately they are disconnected.

(5) *Blue Water Gas may Contain Sulphur Dioxide (SO_2)* as another agent of corrosion. To counter this, it is important that the oxide used in water-gas purifiers should be kept alkaline. This can be effected either by the addition of ammoniacal liquor, soda ash, or slaked lime.

Section B.—EXTRACTION OF HYDROCYANIC ACID.

The chalk process, invented by Mr. J. G. Taplay, has been the subject of experiment for some time past—at first in the laboratory, and afterwards at works on an increasing scale. The process is the subject of letters patent granted to Mr. Taplay and The Gas Light and Coke Company, but will be in due course placed at the service of the gas industry. For this the Committee desire to express their indebtedness to The Gas Light and Coke Company, and their appreciation of Mr. Taplay's research. Application will have to be made to the Secretary of that Company by anyone desiring to use this method of purification.

Briefly outlined, the process is as follows: There are two ways of working—by solid chalk in a scrubber, or by cream of chalk and water in a washer. This will make it possible in many cases to utilize existing plant, or spare plant, of either description. The position of the unit should lie between the tar extractor and the ammonia washer, for it is essential to the reactions that the gas should contain ammonia, but should be free from tar. There is also an incidental advantage in removing the HCN prior to the oxide purifiers, for the small amount absorbed by the oxide impairs the efficiency of the latter for H_2S purification *pro rata*. If a scrubber be used, the solid chalk should be broken into lumps varying in size according to the plant, and this chalk is periodically washed with clean water or weak liquor (not from the hydraulic main). The product, which is ammonium thiocyanate, must be removed as formed. Alternatively, by using a washer, the gas is passed through an aqueous solution of bicarbonate of lime. In either case the chalk appears to act as a catalyst; the reaction becomes cyclic, and hence may be carried out as a continuous operation. It is hoped that this method will provide a simple and expeditious, as well as an economical, means for the removal of hydrocyanic acid from gases, and for the cheap production of ammonium thiocyanate as a bye-product.

Section C.—SOME CASES INVESTIGATED DURING THE PAST YEAR.

Corrosion of Services by Hydrocyanic Acid.—During the last year analyses have been made of deposits found in the services of a large gas undertaking which some time ago ceased to wash for hydrocyanic acid. Previously, such deposits as have occurred have shown no trace, or merely a trace, of prussian blue (ferric ferrocyanide). Now the deposits are becoming more frequent, and the following are some proportions by weight of prussian blue that have been found in recent analyses: 6·9 p.ct., 3·7 p.ct., 2·3 p.ct., 4·5 p.ct. (determinations on the dry basis). Several other examples of corrosion deposit from smaller undertakings have been examined and found to contain prussian blue (ferric ferrocyanide) in varying proportions up to 32 p.ct. by weight.

Corrosion of Cast-Iron Purifiers.—This is a case of overhead purifiers 21 years old, in which bog ore alone has been used. For the last seven years the gas passed through has included coke oven gas mixed with blue, or sometimes carburetted, water gas and with coal gas. The backward rotation system has been in operation, and from 2 to 3 p.ct. of air added for partial revivification. The plates of the purifiers are extensively corroded. In some cases the pitting has gone right through ¾ in. thickness, allowing condensed liquor to percolate. This liquor contained ammonium sulphate, ferrous sulphate, ferric thiocyanate, and ammonium thiocyanate, also giving off SO_2 in the free state. The trouble has arisen from the following causes: (1) Exceptional conditions during coal strike; (2) inadequate purifiers; (3) inadequate cooling plant, allowing ammonia to get past the scrubbers; (4) coke used for water gas with high sulphur content. The immediate remedy suggested is to add slaked lime to the liquors lying in the bottom of the purifiers until they become alkaline.

Another case has occurred almost identical with the above; and the same remedy has been suggested. The conditions are being reproduced in the laboratory with a view to ascertaining what protection could be given to the cast-iron of purifiers in order to resist these particular corrosion salts.

Gasholder Tanks.—In this case the engineer found the water contaminated with cyanogen compounds, and desired to find the cause and prevent corrosion taking place. It appears that some spent liquor from the sulphate plant had got into the tanks. The remedy suggested is the addition to the water of slaked lime moistened to a cream. Subsequent analysis of the water has shown no trace of ammonium thiocyanate, as it was found before; and it may therefore be concluded that the remedy has proved effective.

Gummy Deposit in Station Governors.—This is produced by the polymerization of certain unsaturated hydrocarbons contained in the gas. The presence of sulphur dioxide would assist the action, and therefore the trouble would be most likely to arise with water gas lightly or intermittently carburetted, or in which SO_2 was allowed to go forward. An excess of oxygen in the gas would also influence polymerization. All such deposits may be ameliorated by attention to the temperature of the apparatus in which they occur. Station governors might be protected by heavy lagging, or kept warm in some other way.

Gummy Deposits on Meter Valves.—A strike occurred at a certain gas-works, and the supply was cut off for three

weeks. After resumption, 120 meters were found to have stopped registering. Examination showed that there had been condensation of liquor in the meters which, containing corrosive salts, had rotted the leathers. These leathers had remained sound so long as the meters were working and the valves were free and offered no resistance. The cessation of work, however, during the three weeks had allowed some of the condensed liquor to set and polymerize on the valves. When the gas pressure was resumed, the sticking of the valves put a strain upon the diaphragms, and these, being weak, immediately burst. It is possible also that some air had found its way into the pipes and meters, and this would aggravate both the destruction of the leathers and the viscosity of the deposit on the valves. Here is another illustration of the dictum that a meter with weak leathers and clean valves will go on working correctly much longer than one with good leathers and sticky valves. It will also emphasize the desirability of removing meters from empty houses, and again of corking the inlet and outlet whenever disconnected. The advantage of spraying meters for valve cleaning would also be emphasized.

Section D.—EFFECT OF VAPORIZING PETROLEUM ON THE STUFFING BOXES OF METERS.

A case has arisen where it has been necessary to ascertain what has been the cause of leakage through the stuffing boxes of consumers' meters, following the absorption of grease by some constituents of the gas. Various mixtures are used by different makers for filling stuffing boxes, but tallow is no doubt the commonest ingredient, and this has been tested in the following experiment. Portions of tallow were placed in bottles containing the following: (1) Paraffin oil such as used for vaporizing, (2) benzole, (3) petrol, (4) ammonia solution, (5) a motor spirit known as "Taxibus," (6) coal-tar naphtha. None of these except No. 5 affected the grease; but the "Taxibus" spirit took the tallow completely into solution, and kept it there.

The effect of paraffin oil on leather as used for the diaphragms of meters has been tried. No detrimental result appeared either while the leather was immersed in the paraffin, or afterwards when exposed to the atmosphere.

Section F.—THE NEW STANDARD LIST OF DRY GAS-METERS RATED ACCORDING TO MAXIMUM (EFFICIENT) WORKING CAPACITY.

1.—Inquiries received by the Institution of Gas Engineers from different parts of the country indicate the need for some official explanation of the new Standard List of Dry Gas-Meters, and an authoritative comparison between the new and the old ratings of meters. This, it is felt, would be useful as a guide (*a*) when deciding what meter to fix for any estimated maximum demand, and (*b*) when determining the rentals to be charged for standard meters.

2.—Inquiries made throughout the country by this Committee clearly showed that dry meters were frequently seriously over-worked—that is, were called upon to pass gas at much too rapid a rate in relation to the number of revolutions per hour at which they could be worked without detriment.

3.—The disadvantages of such over-loading of meters included not only undue wear and tear (resulting in a life of the working parts disproportionately short in relation to the service obtained), but also defective registration during periods of over-load. It was demonstrated that a dry meter, when worked materially above the speed at which it was designed to work, registered "slow," and that the percentage of error increased with the rate of over-working.

4.—This deficit in registration through over-loading was seen to be a direct and serious factor in raising the percentage of gas "unaccounted for." That fact had been very generally overlooked because such meters, although registering "slow" while being over-worked on consumers' premises, might, and frequently did, prove correct or even "fast" when brought in and tested under standard test-room conditions.

5.—In view of the above facts, the Committee decided that a new scale of meter sizes should be drawn up, based, not on so many "lights" specified by the makers without definite recognized relation to a normal *rate* of working, but on actual capacity per revolution, with the number of revolutions per hour limited to the number at which it was considered each size might be worked continuously without adversely affecting either the registration or the life of the working parts of the meter.

Number.	Capacity per hour.	Capacity per Revolution.	Revolutions per hour.	Bore of Connections.
	C.Ft.	C.Ft.		Inch.
1	30	0·125	240	$\frac{3}{8}$
2	40	0·166	240	$\frac{3}{8}$
3	60	0·25	240	$\frac{3}{4}$
4	120	0·5	240	1
5	210	1·0	210	$1\frac{1}{4}$
5a	315	1·5	210	$1\frac{1}{2}$
6	420	2·0	210	$1\frac{1}{4}$
7	540	3·0	180	2
8	720	4·0	180	$2\frac{1}{2}$
9	900	6·0	150	3
10	1200	8·0	150	3
11	1800	15·0	120	4
12	3000	25·0	120	5

[Standard list as published in the report for 1921, with the addition of intermediate size referred to in par. 13 below.]

6.—It was further agreed that it was of much importance that meters should be so constructed as to work without serious loss of pressure. This is a point which had not previously received sufficient recognition; but it is believed that many complaints of "bad gas" are really due to insufficient pressure in the consumer's premises caused by undue friction in the working of the meter.

7.—A further matter which the Committee took into consideration in drawing up the new scale of meter sizes arose out of the movement started by the Association of Statutory Inspectors for the Revision of the Sales of Gas Act (1859), which led to the appointment of a Sub-Committee of the Joint Committee to collaborate with that Association in the interests of the gas industry and the meter makers. The result of that collaboration was the embodiment in the Gas Regulation Act (1920) of a provision authorizing the Board of Trade to make regulations for the testing of meters. The regulations subsequently issued have brought testing more into line with actual working conditions. They have raised the initial testing pressure to 20-10ths, and have imposed limitations on the permissible loss of pressure due to the working of a meter at its full rated capacity. The prescribed tests, as well as the fees chargeable for testing, are now based on the maximum quantity of gas per hour the meter is designed to register correctly as stated on the meter, instead of on the number of "lights"—a method of rating now obsolete and practically meaningless.

8.—To meet all the new conditions and requirements, and to establish an absolute basis of comparison between the capacities of meters supplied by different makers, *the new list has been based entirely upon capacity per revolution, with a defined limit to the number of revolutions per hour*, from which the maximum consumption per hour can be calculated. This has resulted, in the case of the larger meters, in a considerable reduction in the speed of working, coupled with an increase in capacity per revolution. There is no doubt that many of the larger size meters now in use are seriously overworked if run at their nominal hourly capacity calculated at 6 c.ft. per hour per light. There have been wide differences between the capacities per revolution in meters of similar nominal capacities but of different makes. This should be carefully borne in mind when comparing the new with the old list of meters. As the valves and internal passages of the new standard meters have been entirely re-designed, these meters will be found more free in working than meters on the old list of comparable external dimensions. In the case of meters of the smaller sizes, the capacity in cubic feet per hour has been increased by modifications of internal design, which allow them to be worked at higher speeds than formerly while conforming with the new regulations in respect of absorption of pressure, and without detriment to the life of the working parts.

9.—The table on p. 837 is submitted as a guide to a fair comparison between meters rated according to the old and the new methods.

10.—In comparing prices and fixing rents, full regard must be had to the fact that the nominal capacity of meters rated according to "Number of Lights" differed widely in many cases from their proper working capacity. The smaller sizes were generally under-rated; the larger sizes were much over-rated.

Comparative Table of new "Standard" Meters and Meters rated by "Lights."

New "Standard" Dry Meters.				Meters rated by "Lights."			
Size.	Connections	Capacity per Rev.	Price as at June, 1922	Size.	Connections	Capacity per Rev.	Price as at June, 1922
	Inch.		£ s. d.	Lt.	Inch.		£ s. d.
				2	½	·083	1 15 10
1	⅜	·125	2 3 11	3	⅜	·125	2 4 9
2	½	·166	2 9 7	5	¾	·166	2 13 9
3	¾	·25	3 2 4				
				10	1	·333	3 9 10
				15	1	·416	4 6 0
4	1	·5	4 6 5	20	1¼	·5	5 2 1
				30	1⅜	·833	6 19 9
5	1¼	1·0	7 17 3				
				40	1½	1·25	8 12 0
5a	1½	1·5	9 12 8	50	1⅝	1·428	9 13 6
				60	1¾	1·666	12 18 0
6	1¾	2·0	14 1 11				
				80	2	2·5	16 7 10
				100	2	2·857*	21 4 7
7	2	3·0	17 19 10				
				120	2	3·3	23 2 3
8	2½	4·0	26 11 3				
				150	3	5·0	33 11 10
9	3	6·0	36 19 6				
				200	3½	6·666	40 6 3
				250	3½	7·3	50 10 6
10	3	8·0	55 5 0				
				300	4	8·3	60 9 4
				400	4	12·5	80 12 6
11	4	15·0	90 19 0				
				500	5	14·285	101 1 0
				600	6	22·222	120 18 9
12	5	25·0	136 0 0	800	7	25·0	161 5 0
				1000	8	33·333	201 11 3

* Considerable variation exists, in several sizes of meters rated by "lights," in the capacity per revolution given by different makers' meters, but the figures in this column represent the capacity given by the large majority.

11.—The Committee strongly recommend the strictest adherence to this table in determining the size of meter to be installed in any case, as thereby, and only thereby, can the advantages be secured which the Committee have been aiming to obtain for the industry—namely, those of long life and minimum repairs with accuracy of registration *in situ*—advantages which can easily be lost by an initial small saving in first cost of meter installed.

12.—In drawing up the new list, it was considered desirable to avoid introducing any new sizes of case or any unions not included in the existing standard list. Bearing in mind that the main object of the new list was to encourage and facilitate the use of meters of adequate working capacity in place of existing ones, which are so frequently overworked, every effort was made to increase the working capacity in each of the standard size cases. This was possible in most cases up to the old 80-light size; but above this it was found impracticable to get even the nominal capacity according to the old list out of the corresponding size of case without exceeding the permissible loss of pressure.

13.—The sizes of connections had to be considered, and they have been arranged as far as possible so that an exchange of meters with the same size of case, rather than of meters of equal capacity, should be possible without changing the caps and linings already attached to the service and house piping. Consequently, where an increased capacity is desirable the change can be made without altering the existing connections; but otherwise it may be necessary to change the existing unions or to use adapters. It will be found that up to No. 4 each new standard size is readily interchangeable with the meter in the old list having the same size of case but a lower capacity. The No. 5 meter is fitted with 20-lt. unions, as the 30-lt. unions were found to be unnecessarily large.

Since the original publication of the standard list, in order to meet a generally expressed wish it has been decided to include a meter intermediate between Nos. 5 and 6. This meter will be called 5A, will have a slightly higher capacity per revolution than the old 50-lt., and will be fitted with 50-lt. unions.

The unions for No. 6 are the same as the old 60-lt. meter. No. 7 is an 80-lt. case with 80-lt. unions. No. 8 is in a 120-lt. case and, having 2½ in. connections, can be made with flanged or union joints as desired. Meters above this size having 3 in., 4 in., and 5 in. connections will usually be made with flanged joints. The retention of the old sizes of unions for given sizes of case involves a slight reduction in capacities of the unions relative to the capacities of the new standard meters. These unions are, however, calculated to pass the quantity of gas for which the standard meter is scheduled without loss of pressure; but they should not by themselves be accepted as a basis for deciding the size of the inlet and outlet pipes connected to a meter, which size must be governed also by the length of piping required.

In conclusion, the Committee desire again to emphasize the detrimental and uneconomical results of working any meter at a rate per hour beyond the number of revolutions specified in the new standard list.

Mr. B. R. PARKINSON introduced the report, and read some extracts from it.

Discussion.

Mr. THOMAS GLOVER (Norwich): I should like to congratulate the Committee upon the result of their twelve months' work. It seems that we are getting to close grips with the subject in a very practical manner, and are getting very valuable information. I do not know what they have in mind in urging the extreme importance of removing traces of ammonia. Allusion is made in the report to the corrosion of services and the corrosion of purifiers. As a matter of fact, this corrosion of purifiers has become a rather serious thing; and I wondered whether the Committee had gone so far as to investigate what the effect of these corrosive condensates is on concrete purifiers. Cast-iron plates are undoubtedly suffering; and I have seen a similar occurrence to the one they refer to, of cast-iron plates being perforated after about twenty years' use. The remedy would seem to be to line the purifier-boxes with ferro-concrete; and if the Committee have any information to give us as to the action of these corrosive condensates on ferro-concrete, it would be a very good guide to us. The Committee, of course, are looking at the removal of ammonia purely from the point of view of the life of gas-meters; but I think probably we find an advantage in leaving traces of ammonia at the outlet of the scrubbers for the purpose of assisting purification. Especially where the purifying material becomes rather acid, the traces of ammonia in the purifiers, of course, have a corrective influence, and improve the life of the oxide of iron, whatever the action may be on the cast-iron plates of purifiers and meters. I rather question whether, if other conditions are right, it affects the life of meters very much.

The Committee also discuss rightly and intelligently the stripping of the gas and its natural lubricants. They say something about there being no royal remedy that can be suggested "without interference with the inevitable tendency of modern gas practice." What is the inevitable tendency of modern gas practice? [Laughter.] I think there will be a division of opinion about the inevitable tendency of modern gas practice; but we probably know to what they refer; and we are on the road to remedying the false estimate of what was good practice some time ago, when it was a matter of getting volume instead of energy from the coal. The Committee also rightly discuss the effect of oxygen on the meter leathers. I have taken the opportunity of examining freshly opened meters from my own undertaking and from some others. I have seen some that were nice and moist, with the valves lubricated and the leathers in a very desirable condition; and I have seen others that were the reverse—very dry, with no signs of lubrication about them. I do not know whether this is because of the presence of too much oxygen or owing to some other undesirable factor which has been brought about by the inevitable tendency of modern gas practice. But there is no doubt about the mischievous effect of free oxygen after purification has been completed; and I think if the oxygen is carefully regulated there ought not to be any oxygen escaping the gauntlet of six or eight purifiers. There ought to be sufficient to assist purification, but not any to get past the purifiers, because I can quite imagine its mischievous results upon steel mains and meters—not only the metal work, but also the leathers.

The writer of this report, whom we thank very much for his labour of love, uses rather homely language in one place. Perhaps it was written for a homely purpose. He recommends wrapping meters in exposed positions in some warm material. It is excusable—we talk about putting on a warm overcoat, &c.—but it is not scientifically correct. I take it he means a good jacket of non-conducting material, to protect the meter from draughts, and so forth, to prevent undue condensation and the effect of moisture in the atmosphere. I was also interested in the matter of the carrying capacity of gas for moisture, and the dew-point, and the question whether gas saturated is able to carry paraffin or naphthalene vapours. It is a very interesting point, and well discussed; and there are some figures given which ought to form a useful permanent record. I do not know whether it has been the experience of many here to get inside a gasholder that is under repair, or a new one, on a hot summer's day; but it is a lesson that is likely to impress itself deeply upon the mind,

to find out what the atmosphere is like inside. You can then easily understand the great evaporation which is taking place from the water in the tank, and which is afterwards condensed in the distributing mains and services. Gases which are laden with one vapour cannot carry another. Which it is that has to be condensed out depends upon certain physical laws which we are not always clear about. The late Mr. William Young and my brother and I took a great interest in this matter some thirty years ago; and we set forth the theory that, if you kept on loading your gas with vapours, you would get a selective condensation taking place. The vapours with the higher boiling-points would be thrust out practically by the loading of the gas with vapours of lower boiling-points. This is a matter of very great interest.

There is also the question of fractional condensation which takes place in our distributing system, and in the meters. I do not know whether the Committee have analyzed the condensates from any of the meters. With coal gas or carburetted water gas we supply a quantity of condensable vapour; and where the gas is naturally short of lubricants of this kind we vaporize into it petroleum oils, which the gas carries to the different stages of the distribution system. But, mind you, it is not paraffin oil you get out of the meters. The paraffin oil you have added in the vaporizer does not come back at any stage in exactly the same condition in which you put it in. The heaviest fractions of paraffin oil come down first, and so fractional condensation goes on from stage to stage; the lower boiling-point fractions coming out at the extreme end—sometimes at the consumer's burner. It would be interesting if the Committee would carry their investigation further, and ascertain what are these condensates that take place with meters in somewhat exposed positions, and see if they are derived from the added vapours or from the coal gas or the water gas, or from a mixture of the lot. At all events, I take it that they have a very beneficial effect in the meters, if the condensation is not too rigorous on the meters; so there may be something in not wrapping them up in warm material, but allowing them to be moderately exposed, so long as they are not exposed to rusting conditions. I throw it out as a suggestion for discussion.

Dr. A. PARKER: It is stated in the report that paraffin vaporization is a remedy or palliative prescribed both for corrosion and naphthalene troubles, but that it has been established that a gas-saturated with water will not hold much paraffin vapour. From the purely physico-chemical standpoint, where we have two substances like water and paraffin, which are not permeable, it is generally recognized that the vapours have no influence on one another, and it is generally understood that the amount of paraffin vapour carried by any gas will not be influenced by the water vapour present, but influenced purely by the temperature of the gas. I should like to ask on what grounds this statement is made—whether it is established that water vapour does have any effect on the paraffin. On purely physico-chemical grounds one would not have expected it.

Mr. THOMAS GOULDEN (London): I notice in the report the suggestion is made that a film of heavy oil on the surface of the waters in meter and holder would lessen evaporation as well as help to preserve the plant itself. I suggest to anyone who is going to try the effect of putting oil into holders, to be particularly careful to put the heavy oil recommended. There is a natural tendency for oil put into a holder to absorb naphthalene; and a thin film of oil left in a holder will gradually absorb so much naphthalene (especially during a hot, sunny day, when the crown of the holder is very hot) that when, at night, the temperature falls, the solution will become super-saturated, and you are very liable to get a sticky mass of naphthalene falling down and being precipitated into the bottom of the gasholder tank. This is particularly the case where any large proportion of carburetted water gas is made; and I venture to suggest that anyone who proposes using oil in the interior of his holders should be sure to change it from time to time, in order that it shall not become saturated by naphthalene, as I have mentioned. I know of one case in which such action took place in a holder after some considerable time. It was a large holder, and was lowered for cleaning, and the holder would not land. Divers were sent down, and the effect of their observations was that the holder had to be put out of action for a considerable time; and some tons of naphthalene were taken out of the bottom of the tank. I suggest that due caution should be used in dealing with this remedy that is suggested in the paper. Mr. Glover made reference to the quality and constituents of the gas. We seem to be working at greater heats, and splitting up the hydrocarbons, which makes the gas of a less oily nature than it was; but it is a good thing for meters and mains to have a gas of an oily nature. This was demonstrated in our Kensal Green District, where, years ago, I put in a Botley carburation plant. We never had any difficulty, as Mr. Parkinson will probably tell you in that district the exception was to find mains or meters in anything but a perfectly good condition. But of later years we have had great difficulties to contend with; and there is no doubt we have had a larger proportion of inerts in our gas than is always advisable. Among those constituents you do not want cyanogen and oxygen. I cannot say how emphatic I am on the undesirability of oxygen going forward into cast-iron mains, especially as we have, in these cast-iron mains, a certain amount of water vapour, which, in combination with the oxygen, is almost sure to cause rust. The very large amount of trouble we are having in services, particularly now, is due to rust. But it is not only in this country. We had a gentleman from Berlin a little time ago, who came very hesitatingly to see us. He did not know what his reception would be; but we always entertained very good feelings towards him—it was Mr. Ernst Körting. There is very great apprehension over there with regard to this matter of mains. Rust is giving a lot of trouble, and he, together with myself and other people who have discussed the matter, put it down to the percentage of oxygen, which certainly has been larger than it should be. Again, beware of too much ammonia. Do not forget that ammonia indirectly tends to destroy mains and services, particularly in hot weather. In the presence of the large amount of sulphur compounds we have now, the two compounds enter into combination, and we get the formation of cyanogen compounds and the evolution of sulphuretted hydrogen; so that we are liable to be shot at in two ways if we have too much ammonia. I quite agree that it is good to let a little ammonia go forward; but to let any excess go forward is dangerous.

Mr. C. F. BOTLEY (Hastings): I intervene because some remarks remind me that a good many years ago, when the question of naphthalene was a great deal in my mind, I was struck with the effect of aqueous vapour in the gas in regard to naphthalene; and one of the methods I actually put into operation—but had to abandon on purely commercial grounds—was that of drying the gas. I felt convinced that aqueous vapour had a great deal to do with the condensation of naphthalene, after atomizing for many years (which I do not want to be confused with vaporizing—they are essentially different) oil into the gas (petroleum products, but no other hydrocarbons). I must confess that I do not quite understand the paragraph to which Dr. Parker has referred. Certainly, practically speaking, there is a tendency for gas not to be greedy, as Mr. Goulden says, in the presence of much aqueous vapour, for petroleum; but it does take it up, and I think a far greater factor in the situation is the temperature of the gas. One does not find a failure to carry atomized petroleum in the summer time; but possibly, for the reason indicated by Mr. Glover, we certainly do not find such a good carrying power for the gas as in the winter. It is also very gratifying to find the plant Mr. Goulden has been good enough to honour me by mentioning, has fulfilled his expectation. One of the meter makers told me that petroleum would have no effect on the leathers; and that is borne out in practice to-day. It may also be of interest to tell the members that, so far as my experience goes, to the best of my belief we have no more trouble to-day with meters on the district at Hastings and St. Leonards than we have ever had. Another curious thing is that the bulk of the products of condensation from the mains has been a decreasing amount for a great many years. This bears also on the question of the carrying power of aqueous vapour.

Mr. SAMUEL GLOVER: Before this discussion is closed, may I commend to all our young members of the Institution the study of the extraction of hydrocyanic acid. Sometimes our young men wonder what there is left for them to do in the industry. I am always trying to preach the gospel that the last word has never been said; and nobody ought ever to presume to think that it has been said on any subject we have to deal with. I am very pleased to see that the work of this Committee—who have been doing good work for the Institution for several years—is so highly commended to-day; and I would like to tell the members that very good work has been done for them, and to remind them, or inform them, of the discovery of the effect of the use of "Taxibus," a spirit being employed for vaporization into the gas. The Committee were distinctly responsible for the discovery of the effect of this spirit, which is one of those spirits which should not be used in connection with gas apparatus, because it has a solvent effect upon the tallow or grease, or whatever substance is being used in the packing of the stuffing boxes of dry meters. The discovery of the effect of this Taxibus stuff on the stuffing boxes of dry meters was declared to be worth all the trouble that the Committee have given to the subject. I just mention this as proof that the Committee are doing very good work for you. I should like those preparing reports to use, not pedantic, but rather more correct language in describing what they mean when giving their reports. On p. 3 of this report I am sorry to see the words "If water-gas tar oil be used for this purpose, it should first be dehydrated, and then the lighter portions distilled off." Surely I am quite correct in describing that as very vague. In whatever other way would you distil these things without first driving the water off? If you go on to describe the operation, we could tell our friends how far to go with the distilling-off of the lighter portions and which portions are used in the operation altogether—describe whether it is the lighter portions which are to be distilled-off or what remains after the distillation of some portions of the oil. I want to emphasize and commend to the searching investigation of any of our members who have any aspiration—any desire to do good work for themselves, for the industry, and for the companies they serve, in following up this extraction of hydrocyanic acid. Having had some experience of Kenneth Jones's process for the extraction of these troublesome acids, and having an idea that we ought, as gas engineers, to turn out our gas free from these viscous compounds, I have watched with very great interest the development of

Mr. Taplay's discovery—I think that is the right word—of a simple reagent which he has found to be useful in this process. The process commends itself to me as being a very simple one for which any young engineer could fit up the apparatus, and conduct experiments, at his own works, especially if he is one of those who is carbonizing certain coals at a high temperature, which is not the general practice everywhere. It has not become the royal road to gas making, the carbonizing of certain coals at a high temperature. High-temperature work is not universally being adopted throughout the carbonizing world; but anybody making hydrocyanic acid can conduct experiments on this process. I believe I am right in saying—and I believe we were told this afternoon that application will have to be made to the Secretary of the Gas Light & Coke Company for permission to use this process, or for the acknowledgment of some royalty for permission to use the process—that the acknowledgment of the Gas Light & Coke Company will be given nominally, and they will not stand in the way of anyone wishing to experiment.

Mr. JOHN WILKINSON (Nottingham): I should not have spoken on the report, had it not been for the reference by the previous speaker to the removal of the hydrocyanic acid from the gas; and I desire to take the opportunity of asking the opinion of the authors of the report with regard to the suggested total elimination of ammonia from the gas as it leaves the scrubbers, combined with what, I think, has become a general tendency towards dry purification—*i.e.*, using oxide containing as little moisture as possible. The point upon which I would like their opinion is this. If you eliminate entirely the ammonia from the gas, and pass it through dry oxide, is there not a tendency to remove the conditions which probably bring about the formation of a certain amount of ammonium sulphur cyanide and other compounds of cyanogen in the purifiers, and so obtain an opposite effect to that which you had originally in mind? Another matter in which I think the authors are somewhat at fault is in their suggestion that the change over from lime to oxide purification has had an important bearing upon the shortened life of gas-meters. I have not used lime purification for the last thirty years; but the whole of my meter troubles have come along within the last ten years. I realize that the modern, or recent, tendency has been to send out gas containing more inerts (which, of course, include CO_2), and I also realize that the effect of this is exactly similar to the turnover from lime to oxide; but I suggest that force of circumstances compelled us to do so, and I do not think that the original turnover from lime to oxide seriously affected the gas-meters.

Mr. A. W. GLOVER: I should like to mention a section of the report which has not received much attention, and that is section (*f*), "Memorandum on the New Standard List of Dry Gas-Meters rated according to Maximum (efficient) Working Capacity." I consider it a very valuable section of the report, and it answers a good many questions which have been asked. Mr. Parkinson, in his introduction, gave too much credit to the Society of British Gas Industries, in suggesting we had rejected this section. As a matter of fact, it was rejected by the Life of Meters Committee themselves, by the fact that inquiries had been received from various gas engineers, as shown in paragraph 1 of this section, and questions were asked as to what rentals should be fixed for the new standard meters, and what size meters should be fixed for any particular demand. The Committee went into the matter, and the Sub-Committee drew up their report. I commend it to the very careful attention of members, and I believe myself that the new standard meters, if used generally, will be of very great benefit to the industry.

Mr. J. G. TAPLAY: I should like to make a few remarks on what has been said. In reply to Mr. Thomas Glover, of Norwich, I may say that the corrosion of gas services and meters takes place from two sources. The carbon bisulphide and ammonia in the gas interact, and form the ammonium sulphur cyanide, which, in the presence of moisture, will dissolve ironwork. There is another, which is just as destructive, if not more so, and that is the combination of hydrocyanic acid and ammonia in the gas, in conjunction, of course, with water vapour. Mr. Glover also referred to the cast-iron plates of purifiers. I have had an opportunity of investigating this point, and I find there is a great deal of corrosion in different works in the country, solely due to this ammonium cyanide and ammonium sulphur cyanide. By far the greater quantity is the ammonium sulphur cyanide in solution; and I am at present experimenting with some cast iron from a purifier plate to see what we can do towards its preservation. It may be that painting it over with ordinary tar, or with prepared tar, such as is used for road work, might have the desired effect; but it will take some months before the experiment is completed. I cannot say very much about it now; but a piece of iron from the same plate, which was not painted at all, is rapidly becoming dissolved in the absence of air. It is sealed up in a bottle, with coal gas over the surface of the liquid, and ferrous sulphocyanide is being formed. If tarred plates do not prove successful, we shall propose some other means—say, oxide paint, or something of that sort. Anyway, what is really wanted is something cheap. Mr. Glover mentioned ferro-concrete for covering the plates. I am not sure that this would not be disintegrated in a short time. I do not like the idea; but as the suggestion has been put forward I think it is only right and proper that it should be tried. About the ammonia on the outlet scrubbers used for keeping the purifiers alkaline; I do not know whether Mr. Glover thought this chalk process for the removal of hydrocyanic acid was going to take all the ammonia out. It is not. It will only take out ammonia equivalent to its own weight. You would be surprised that the amount is very small; but it is very effective. As to modern gas practice, perhaps I had better not say too much about that. The inevitable practice, no doubt, with ordinary retorts, where you do not employ steam, is to produce more and more hydrocyanic acid, and as in these days the gas supplied is drier as regards oily matter than it used to be, your services or meters are more affected than in times past. As to the desirability of the Committee to making analyses of condensates from meters, that has already been done, and we have found that these liquid condensates, other than water, consist of mixtures of benzole, coal tar, naphtha, creosote oil, and certain fractions of paraffin. I do not say the heavy paraffin. I have known paraffin oils from the district which boil between 200° and 300° C. They have travelled very slowly; but they do get there eventually. With regard to the crude water-gas tar oil on the surface of the water in the meters and holders, if you are going to use that on the surface of the water of the gasholder tank, it is best to, first, carefully drive-off the water, and then the lighter oil, because if you are not careful you get frothing; and this might cause fire. So that when dehydrating the water-gas tar oil, there is water on top and a certain amount of light oils, and we have to be very careful. As to Mr. Wilkinson's remarks, would he like to say why it is necessary to produce ammonium sulpho cyanide in purifiers? It is present, it is true; but I do not see that it is necessary, and you do not want it in the purifiers. You do not want to mess up your oxide. You do not want that any more than you want the Prussian blue. So long as you get a sufficient amount of ammonia in the purifiers, the oxide will be far better without ammonium sulpho cyanide. That is why it is proposed to remove cyanides by means of chalk. We are now about to engage in a large-scale experiment at the Bow Common Works of the Gas Light and Coke Company; and in this particular case the scrubber containing the chalk which is broken to from ¾-in. cube to 1½-in. cube, goes after the washer, and the washer is preceded by the condenser and the tar extractor. This scrubber contains eight tiers of ordinary wooden purifying grids; and each tier holds four tons of chalk. The total weight is about 30 tons. The crude gas, containing ammonia, sulphuretted hydrogen, hydrocyanic acid, and carbon dioxide, passes through this scrubber. The chalk is first damped by means of an intermittent water spray, and the chalk acts as a contact agent; the real agent for the absorption being the calcium or magnesium bicarbonate which it may contain. All the chalk contains either one or the other, and each is effective. The product which is formed on the surface of the chalk in the presence of water is ammonium sulpho cyanide. This is washed by means of a water spray at the top of the scrubber, and the carbon dioxide coming along with the crude gas keeps the chalk in the carbonate state. The amount of hydrocyanic acid in the gas tested at the present time is equivalent to 2¾ lbs. of Prussian blue, equivalent to 91·5 grains per 100 c.ft. of gas; sulphuretted hydrogen, 115 grains; and your ammonia is 57½ grains; whereas you had about 600 grs. of H_2S. to begin with, and also 150 to 160 grs. of ammonia. This scrubber is being put into action within the next day or so, and about 2½ million c.ft. of gas at the present time passes through in twenty-four hours in the summer time. There is one thing one must always remember in a process of this kind, and that is that your tar must be thoroughly removed from the gas.

Mr. THOMAS GLOVER: Will Derbyshire limestone take the place of chalk?

Mr. TAPLAY: Owing to its crystalline structure, it is of no value whatever.

Mr. PARKINSON: There are one or two points to which I should like to refer. The Committee did not wish to put a great deal of chemical technology into this report. That is, perhaps, why it is written in "homely language." In the report for 1920, all the formulæ for the corrosive salts were given by Mr. Taplay. I have no doubt Mr. Taplay will be pleased to make some experiments as to the influence of the corrosive salts on concrete. With regard to the words "inevitable tendency" of modern gas practice, and the criticism of Mr. Thomas Glover, the best way to meet this would be to leave out these two words, and read "without interference with modern gas practice." [Laughter.] I see that the report is still subject to revision. But I would not like to adopt any suggestion of alteration with respect to the homely language regarding the warm material for wrapping the meter. If you go to a consumer's house, and ask the householder for some warm material she will give it to you; but if you were to ask for insulating material [Laughter] she might not know what you wanted. Just one other thing. I would suggest also the omission of the word "established" in the sentence: "It has been established that a gas saturated with water will not hold much paraffin vapour," and the substitution of "suggested." That came from an article which appeared in the "GAS JOURNAL" for Aug. 3, 1921, by Norman Swindon, A.M.I.M.E. It is very interesting; and to me it seemed convincing. The author of the article gave numbers of experiments by which he claimed to have proved his point.

The PRESIDENT: The suggestion for alterations put forward by Mr. Parkinson will be referred to the Committee.

REPORT OF THE REFRACTORY MATERIALS RESEARCH COMMITTEE.

As outlined at the meeting in October last, experiments were then in hand for the improvement of the test for after contraction or expansion, as laid down in the Institution's Standard Specification for Refractory Materials.

The specifications have been in operation since November, 1912, and have been acknowledged as having resulted in very great improvements in the manufacture of firebricks, retorts, &c., not only in our own industry, but in other industries which use refractories.

Experience, however, (as was anticipated) has shown that considerable amendment is required in the standard specification and tests, and the work of revision is already well in hand.

In regard to the retort specification, it was only contemplated that retorts would be made from fireclay with an admixture of grog; but it is necessary at the present time to add silica and siliceous materials, aluminous material and carborundum, or anything else that is suitable, and also mixtures of any of these substances.

Clause 3 has required a great deal of careful attention. The test piece is required to show no signs of fusion at a given temperature. It sounds simple enough; but the difficulty is to determine what is and what is not a sign of fusion. No other words, however, seem to make a suitable substitute. Dr. Mellor specially wishes to point out that squatting, signs of fusion, rounding corners, &c., all fail in the specification. In the notes and appendix on this clause there was an attempt to define signs of fusion, but experience has shown that the definition is not satisfactory. The best way to meet all views appears to be to define signs of fusion as being "when the angular edges of the test piece begin to lose their angularity when heated under conditions stated." Neither should the test piece, which should be 1½ in. high by ¾ in. base and the same shape as the cone, show signs of bending, nor should the matrix show signs of melting. The specification will probably be finally amended somewhat in this way.

Most experimenters prefer to grind the test-piece to shape, as the triangular cone is more easily formed by this method; while others prefer to chip it as nearly as possible to shape, as the angular edges are then more susceptible to the rounding effect due to fusion.

The contraction test has also been difficult to carry out in practice. The size specified, 4½ in. long by 4½ in. wide, was found to be too large, and test pieces now are preferred 2½ in. to 3½ in. by 1½ in. to 2 in. by 1½ in. to 2 in., and instead of being placed horizontally should now be placed vertically. Difficulty has also been experienced with taking the measurements on account of varying behaviour of various parts of the test-pieces, and an endeavour is being made to overcome this difficulty by allowing a tolerance of 1 p.ct. for an experimental error in order to secure better agreement between tests made by different experimenters.

The specification for contraction or expansion has been stiffened up by reducing it to 1 p.ct. instead of 1¼ p.ct. Similarly corresponding alterations are required in regard to firebricks, blocks, and tiles, and in regard to silica bricks, blocks, and tiles. The work of revision will soon be complete, and the new edition of standard specifications will shortly be in the printer's hands.

Meanwhile, further valuable work has been carried out at Stoke, the result of which will be found in the following papers.

REVISION OF SPECIFICATION.

STANDARDIZATION OF THE AFTER-CONTRACTION TEST.—PART I.

Preliminary Report.

By Miss D. A. JONES, B.Sc.

Considerable experience with the after-contraction test has made desirable a revision of the original method devised when our knowledge of the subject was less complete. It has been found that tests with different portions of the same brick do not always give concordant results; and therefore it is very necessary that some method should be devised which will minimize the errors of experiment.

Up to the present, the test has been carried out on small pieces of material, the ends of which are ground flat on a carborundum wheel, and the contraction measured by means of Vernier callipers reading to 0·1 mm. In some cases—*e.g.*, portions from special shapes—the amount of material available is insufficient to obtain a specimen of specification size (viz., 4½ in. by 4½ in.).

The following tests were made on the whole brick, instead of smaller pieces. The idea was to find if a better average could be obtained with larger pieces. The Institution of Gas Engineers Committee selected relatively small test-pieces, because it was thought that the test would be easier with small than with large pieces. It is not easy to get a small testing-furnace uniformly to heat large pieces. Two measurements were taken along the length, and two along the width of the brick-face; and the mean of each pair of readings is taken. The temperature was raised over a period of four hours, and maintained at the maximum (*i.e.*, Cone 14 for firebricks and Cone 12 for silica bricks) for a further period of two hours, in order to ensure a thorough soaking of the bricks. The temperature is determined by an accurate pyrometer, and checked at short intervals—*e.g.*, every quarter-hour. It is, however, desirable to use cones as indicators, as pyrometers can easily give incorrect results. But, on the other hand, when the appropriate cone has squatted, it ceases to give any further indication of the temperature, and therefore the pyrometer must be relied on for the constant temperature period. Cones, of course, *per se* do not measure temperatures.

METHOD OF PROCEDURE.

The bricks are heated in a surface combustion furnace which gives a clear and even heat. The furnace is easily manipulated so that the rise of temperature is very readily regulated. The air inlet is kept open as much as possible, so as to ensure an oxidising atmosphere. In order to obtain comparative figures, small pieces 3 in. by 2 in., are fired at the same time as the whole bricks. Two of these are taken parallel to the length, and two parallel to the width of the brick, respectively.

Great care must be exercised in the heating of silica bricks, as they easily fracture if too suddenly heated. The flame must not be allowed to impinge on the bricks when lighting-up the furnace. To obviate this difficulty, a screen is placed between the bricks and the burners on each side of the furnace. The iron sheets are removed when the furnace has become thoroughly warmed.

Six different types of brick have been tested; and the figures obtained will be found in the accompanying table. An examination of the results shows considerable diversity in the readings, even in the same brick. In some cases it is very difficult to get an exact reading, because, after firing, the small pieces of grog seem to project, and thus spoil the readings obtained by the callipers. In some cases, because of this trouble, the readings have been discarded altogether. No. III. gives a typical example in the variation of the readings; for in three of the bricks there is expansion, while the fourth shows contraction. This particular test, however, will be repeated for verification.

Various sources of error may be suggested. Unequal mixing of the ingredients, and insufficient firing in the manufacture of the brick, may prove to be a serious source of error. Then, again, during the burning of the bricks, the end of the brick nearer the "bag" will probably be burnt more than the other end, thereby causing a diversity in the results. The chief source of error seems to be the dislocation of the surface of the brick after firing. Consequently, the callipers measure not only the change in length, but also an indefinite surface change. These experiments show that the errors are not eliminated by using whole bricks for the test; and the following method of testing has been suggested by Dr. Mellor: Two marks are made on the brick at a convenient distance apart—say, 18 cm.—and the distance measured before and after the firing by a pair of measuring microscopes. This method will form the subject of a later report. (See below.)

Results of Experiments on Whole Bricks.

Small Pieces from Length.		Whole Bricks Change in Length.		Small Pieces from Width.		Whole Bricks Change in Width.	
Per Cent. Change.	Mean.	Per Cent. Change.	Mean.	Per Cent. Change.	Mean.	Per Cent. Change.	Mean.
I. (*a*) − 0·1739 (*b*) − 0·1240	− 0·149	A (*a*) − 0 0265 (*b*) − 0·0622 B (*a*) − 0·0446 (*b*) − 0·0355 C (*a*) − 0·0620 (*b*) − 0·0531 D (*a*) − 0·0532 (*b*) − 0·0531	− 0·044 − 0 040 − 0·057 − 0·0531	(*a*) − 0 1432 (*b*) − 0·1507	− 0·147	A (*a*) − 0·0724 (*b*) − 0·0546 B (*a*) − 0·0360 (*b*) − 0·1627 C (*a*) − 0·1265 (*b*) − 0·0905 D (*a*) − 0·0899 (*b*) − 0·0899	− 0 063 − 0·099 − 0·108 − 0·089
II. (*a*) − 0·227 (*b*) − 0·1947	− 0·211	A (*a*) − 0·0896 (*b*) − 0·0805 B (*a*) − 0·1074 (*b*) − 0·1433 C (*a*) − 0·4317 (*b*) − 0·4393 D (*a*) − 0·4711 (*b*) − 0·4340	− 0·085 − 0·125 − 0·435 − 0 452	(*a*) − 0·3294 (*b*) − 0·4558	− 0·393	A (*a*) − 0 0529 (*b*) − 0·2678 B (*a*) − 0·1358 (*b*) − 0·1792 C (*a*) − 0·3734 (*b*) − 0 4767 D (*a*) − 0·5196 (*b*) − 0·5344	− 0·161 − 0·157 − 0 425 − 0·527
III. (*a*) − 0·1266 (*b*) − 0 1042	− 0·115	A (*a*) + 0·1584 (*b*) + 0·1762 B (*a*) + 0·1497 (*b*) + 0·1772 C (*a*) + 0·1148 (*b*) + 0·0614 D (*a*) − 0·1237 (*b*) − 0·1051	+ 0·167 + 0·163 + 0·088 − 0 114	(*a*) − 0·1016 (*b*) − 0·0498	− 0·076	A (*a*) + 0·1995 (*b*) + 0·2178 B (*a*) + 0·1453 (*b*) + 0·1276 C (*a*) + 0·0712 (*b*) + 0 0715 D (*a*) − 0·1798 (*b*) − 0·0892	+ 0·208 + 0·136 + 0·071 − 0·134
IV. (*a*) + 0·1311 *b*) + 0 2621	+ 0·197	A (*a*) − (*b*) − B (*a*) − (*b*) − C (*a*) − (*b*) − D (*a*) − 0·071 (*b*) −		(*a*) + 0·1909 (*b*) + 0 1669	+ 0·179	A (*a*) + 0·0881 (*b*) + 0·2099 B (*a*) + 0·0528 (*b*) + 0·2119 C (*a*) (*b*) + 0·0884 D (*a*) + 0·1404 (*b*) + 0 0848	+ 0·149 + 0·132 + 0 088 + 0·112
V. (*a*) + 0·518 (*b*) + 0·1012	+ 0·077	A (*a*) + 0·2387 (*b*) + 0·1761 B (*a*) + 0·2125 (*b*) + 0·1586 C (*a*) − (*b*) + 0·1756 D (*a*) − (*b*) + 0·2282	+ 0·207 + 0·185 + 0·175 + 0·228	(*a*) + 0·1571 (*b*) + 0·1547	+ 0·156	A (*a*) + 0·1469 (*b*) + 0 2367 B (*a*) + 0·1293 (*b*) C (*a*) + 0·0906 (*b*) + 0·0908 D (*a*) + 0·1988 (*b*) + 0·0912	+ 0·192 + 0·129 + 0·091 + 0·145
VI. (*a*) + 0·0270 (*b*) + 0·0266	+ 0·027	A (*a*) + 0·0530 (*b*) − B (*a*) + 0·0709 (*b*) + 0·0881 C (*a*) + 0·0532 (*b*) − D (*a*) + 0·0892 (*b*) + 0·0887	+ 0·053 + 0·079 + 0·053 + 0·089	(*a*) + 0·0796 (*b*) + 0·0794	+ 0·079	A (*a*) + 0·0554 (*b*) + 0·0182 B (*a*) + 0·0551 (*b*) + 0·0184 C (*a*) + 0·1085 (*b*) + 0·0554 D (*a*) + 0·1074 (*b*) 0·0000	+ 0·037 + 0·037 + 0·081 + 0·051
VII. (*a*) + 0·1090 (*b*) + 0·1530	+ 0·131	A (*a*) + 0·1309 (*b*) + 0·1396 B (*a*) + 0·1486 (*b*) + 0·1399 C (*a*) + 0·1573 (*b*) + 0·1749 D (*a*) + 0·1477 (*b*) + 0·1826	+ 0·135 + 0·145 + 0·166 + 0·165	(*a*) + 0·1354 (*b*) + 0·1618	+ 0·148	A (*a*) + 0 1061 (*b*) + 0·0883 B (*a*) + 0·1415 (*b*) + 0 1413 C (*a*) + 0·1421 (*b*) + 0·1237 D (*a*) + 0·1751 (*b*) + 0·1579	+ 0·097 + 0 142 + 0·133 + 0·167
VIII. (*a*) + 0·1299 (*b*) + 0·1003	+ 0·115	A (*a*) + 0·2966 (*b*) + 0·3309 B (*a*) + 0·1609 (*b*) + 0·2221 C (*a*) + 0·2322 (*b*) + 0·1517 D (*a*) + 0·3229 (*b*) + 0·2057	+ 0·314 + 0·192 + 0·192 + 0·265	(*a*) + 0·1839 (*b*) + 0·1557	+ 0·165	A (*a*) + 0·1433 (*b*) + 0·1450 B (*a*) + 0·0539 (*b*) + 0·0882 C (*a*) + 0·0905 (*b*) + 0·1257 D (*a*) + 0·1078 (*b*) + 0·1800	+ 0·144 + 0·071 + 0·109 + 0·144
IX. (*a*) − 0 0267 (*b*) − 0·0528	− 0 040	A (*a*) 0·000 (*b*) + 0·0442 B (*a*) + 0·0706 (*b*) + 0·0533 C (*a*) + 0·0972 (*b*) + 0·0620 D (*a*) − 0·008 (*b*) 0·000	+ 0·022 + 0·062 + 0·079 − 0·004	(*a*) − 0·0267 (*b*) − 0·0251	+ 0·026	A (*a*) 0·000 (*b*) 0·000 B (*a*) + 0·1095 (*b*) + 0·0734 C (*a*) + 0·1091 (*b*) + 0·1820 D (*a*) 0·000 (*b*) + 0·018	0·000 + 0 092 + 0·145 + 0 009
X. (*a*) − 0·6569 (*b*) − 0·6439	− 0·650	A (*a*) + 0·1411 (*b*) + 0·2027 B (*a*) + 0·1148 (*b*) + 0·1468 C (*a*) + 0·1408 (*b*) + 0·0794 D (*a*) + 0·2017 (*b*) + 0·1754	+ 0 172 + 0·131 + 0·110 + 0·189	(*a*) − 0·7202 (*b*) − 0·6770	− 0·699	A (*a*) + 0·2514 (*b*) + 0·2509 B (*a*) + 0·1086 (*b*) + 0·1086 C (*a*) + 0·0546 (*b*) + 0·1643 D (*a*) + 0·2155 (*b*) + 0·1604	+ 0·251 + 0·109 + 0·109 + 0·188

The + sign indicates expansion. The − sign indicates contraction.

NOTE.—No. X. is a repetition of No. III., and again the measurements show expansion in the whole bricks but contraction in the small pieces.

THE STANDARDIZATION OF THE AFTER-CONTRACTION TEST.—Part II.

By Miss D. A. JONES, B.Sc.

In certain cases there is some difficulty in getting concordant results in the measurement of the after-contractions of refractory materials, while occasionally even absurd results may be obtained. This has been traced to the formation of little surface scabs of a ferruginous nature. These scabs prevent the jaws of the callipers making proper contact when the latter are placed in position for the measurement. If the scabs are small and sporadic, they can be cut off; but often they require to be ground—a process which is a fatal objection to the method of measurement. Another objection to the method arises

from the fact that in preparing the test-pieces plane surfaces have to be ground. During this grinding some of the exposed siliceous grog is almost certain to be disturbed; and this may be exaggerated in the firing. The result is that the measurement may be useless as a criterion of the after-contraction under the test conditions.

I, therefore, tested a modification of the method of measurement. In this method the distance between two points on the brick was determined, before and after firing, by means of a pair of measuring microscopes, one of these being fixed. Two measurements were taken along the length and two across the breadth of the brick face, as in

TABLE I.

Brick Number.	Lengthwise.						Crosswise.					
	Small Piece (7 cms. approx.).			Whole Brick (18 cms. approx.).			Small Piece (7 cms. approx.).			Whole Brick (7 cms. approx.).		
	Change.	Deviation from Mean.	Mean.	Change.	Deviation from Mean.	Mean.	Change.	Deviation from Mean.	Mean.	Change.	Deviation from Mean.	Mean.
	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.
I.	+0·03 +0 03	±0·00	+0·03	A −0·17 −0·18	±0·005	−0·175	+0·03 +0 03	±0·00	+0·03	A +0·04 +0·04	±0·00	+0·04
				B +0·02 +0·02	±0·00	+0·02				B +0·06 +0·06	±0·00	+0·06
				C −0·05 −0·04	±0·005	−0·045				C −0·06, −0·06, −0·09, −0·09	±0·015	−0·075
				D .. −0·07	..	−0·07				D −0·35, −0·34		−0·345
II.	−0 14 −0·15	±0·005	−0·145	A −0·07 −0·06	±0·005	−0·065	−0·15 −0 15	±0·00	−0·15	A −0·00 −0·05	±0·025	−0·025
				B −0·03 −0·02	±0·005	−0·025				B −0·00 −0·00	±0·00	−0·00
				C −0·02 −0·02	±0·00	−0·02				C −0·00 −0·01	±0·005	−0·005
				D −0·11 −0·09, −0·09	±0·01	−0·10				D −0·14, −0·14, −0·15, −0·15	±0·005	−0·145
III.	−0·22 −0·23	±0·005	−0·225	A −0·01 −0·01	±0·00	−0·01	−0·25 −0·25	±0·00	−0·25	A −0·31 −0·32	±0·005	−0·315
				B −0·16 −0·14	±0·01	−0·15				B −0·37 −0·39	±0·01	−0·38
IV.	−1·22 −1·20	±0·01	−1·21	A −0·88, −0 88	±0·015	−0·865				A −1·01 −0·96, −0·97	±0·022	−0·987
				B −0·85 −1·35, −1·36	±0·01	−1·345				B −1·40, −1·42	±0·007	−1 418
				−1·33, −1·34						−1·43, −1·42		
V.	+0·14 +0·12	±0·01	+0·13	A +0·03 +0·03	±0·00	+0·03	+0·12 +0·13	±0·005	+0·125	A +0·04 +0·04	±0·00	+0·04
				B +0·03 +0·02	±0·005	+0·025				B +0·02 +0·01	±0·005	+0·015
				C +0·05 +0·04	±0·005	+0·045				C +0·00 +0·00	±0·00	+0 00
				D +0·07 +0·07	±0·00	+0·07				D +0·01 +0 01	±0·00	+0·01
VI.	+0 06 +0·06	±0·00	+0·06	*A +0·07 ..		+0·07	+0·05 +0·06	±0·005	+0·055	A +0·10 +0·10	±0·00	+0·10
				B +0·08 +0·07	±0·005	+0·075				B +0·10 +0·10	±0·00	+0·10
				*C +0·07 ..	..	+0·07				C +0·09 +0·09	±0·00	+0·09
				D +0·08 +0·08	±0·000	+0·08				D +0·04 +0·04	±0·08	+0·04
VII.	+0·02 +0·02	±0·00	+0·02	A +0·18 +0·18	±0·00	+0·18	+0·02 +0·02	±0·00	+0·02	A +0·01 +0·02	±0·005	+0·015
				B +0·05 +0·05	±0·00	+0·05				B +0 01 +0·01	±0·00	+0·01
				C +0·16 +0·16	±0·00	+0·16				C +0·02 ..	..	+0·02
				D +0·12 +0·12	±0·00	+0·12				D +0·12 +0·11	±0·005	+0·115
VIII.	+0·15 +0·16	±0·005	+0·155	A +0·08 +0·08	±0·00	+0·08	+0·15 +0·15	±0·00	+0·15	A +0·13 +0·13	±0·00	+0·13
				B +0·08 +0·08	±0·00	+0·08				B +0·10 +0·10	±0·00	+0·10
				C +0·06 +0·05	±0·005	+0·055				C +0·10 +0·09	±0·005	+0·095
				D +0·07 +0·07	±0·07	+0·07				D +0·09 +0·10	±0·005	+0·095
IX.	+0·35 +0·35	±0·00	+0·35	A +0·28 +0·26	±0·01	+0·27	+0·29 +0·29	±0·01	+0 28	A +0·23 +0·25	±0·01	+0·24
				*B +0·27 ..	..	+0·27				B +0·27 +0 27	±0·00	+0·27
				C +0·29 +0·28	±0·005	+0·285				C +0·29 +0·28	±0·005	+0·285
				D .. +0·28	..	+0·28				D +0·33 +0·32	±0·005	+0·325

TABLE I.—*Continued.*

Brick Number.	Lengthwise.						Crosswise.					
	Small Piece (7 cms. approx.).			Whole Brick (18 cms. approx.).			Small Piece (7 cms. approx.).			Whole Brick (7 cms. approx.).		
	Change.	Deviation from Mean.	Mean.	Change.	Deviation from Mean.	Mean.	Change.	Deviation from Mean.	Mean.	Change.	Deviation from Mean.	Mean.
	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.	P.Ct.
Xa	+0·09 +0·09	±0 00	+0 09	*A .. +0·106	..	+0·106	+0·10 +0·11	±0·005	+0·105	A +0·05 +0·05	±0·00	+0·05
				*B .. +0·111	..	+0·111				B +0·13 +0·12	±0·005	+0·125
				*C ..	..	..				C +0·08 +0·08	±0·00	+0·08
				*D ..	..	..				D +0·09 +0 09	±0·00	+0·09
Xb.	+0·00 +0·00	±0 00	+0·00	*A .. +0·04	..	+0·04	+0·00 +0·00	±0·00	+0·00	A +0·04 +0·04	±0·00	+0 04

NOTE I.—* Readings could not be taken owing to cracks in the bricks.
NOTE II.—+ sign indicates expansion; − sign indicates contraction.

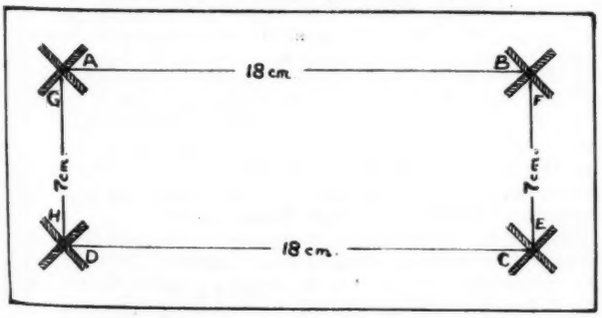
TABLE II.

Brick Number.	1st Firing.		2nd Firing.	
	Change.	Deviation from Mean.	Deviation from Mean.	Change.
	P.Ct.	P.Ct.	P.Ct.	P.Ct.
I.	A +0·10 +0·06	±0·02	±0·01	+0·10 +0·08
	B −0·21 −0·17	±0·02	±0·01	−0·43 −0·45
II.	A −0·18 −0·17 −0·10	±0·037	±0·01	−0·19 −0·19 −0 17
III.	A −0·29 −0·19	±0·05	±0·005	−0·45 −0·44
	B −0·82 −0·73	±0·045	±0·015	−0·82 −0·85
	C −0·94 −0 80	±0·07	±0·00	−0·95 −0·95
	D −0 29 −0·29 −0·17 −0·15	±0·065	±0·025	−0·30 −0·30 −0·25 −0·24
IV.	A +0·29 +0·30 +0·14	±0 08	±0·03	+0·37 +0·37 +0·31

NOTE.—The brick numbers in Table II. correspond with those in Table I.

the preliminary series of tests. The test was carried out on small pieces (3 in. by 2 in.) also; the measurement of two of these pieces being taken parallel to the length and two parallel to the breadth of the brick in the case of each type. The small pieces were cut out of one brick.

The points determining the length measured were obtained in the following manner (see diagram).



Two grooves (approximately 1½ mm. in depth) are cut at right angles to each other in the face of the brick by means of a tin circular saw fed with fine carborundum. The grooves thus formed have a sharp edge and a well-defined point at the intersection of two edges. Four such crosses are cut in the brick-face, as illustrated above; the distances apart being about 18 cm. for the "length" measurements and about 7 cm. apart for the "breadth" measurements. The fixed miscroscope is focussed over one point of intersection, say A, and the movable one adjusted until focussed over the point B; the length being deduced from these two readings. The other measurements are obtained in a similar manner.

Care must be taken to remove, before firing, the carborundum from the grooves, as this material tends to blister and obliterate the points used for measurement.

The experimental conditions are precisely similar to those in the previous series of tests. Further description of the general procedure is, therefore, unnecessary.*

The results are summarised in Tables I. and II. appended.

On reference to the figures for the whole bricks (Table I.) it will be found that, although the two readings for one particular brick are in agreement, in most instances an appreciable difference is found between individual bricks even of the same type. Therefore the result obtained from a test on one brick cannot be taken as a true representative value for all the bricks of that type. This is possibly due to the uneven firing in the kiln during the manufacture of the bricks.

In comparing the results for the small pieces and the whole bricks, one would expect a greater contraction or expansion in the small pieces on account of the latter possibly undergoing a more thorough "soaking." The fact that no systematic differences between the two sets of results were noted may arise from the causes indicated above.

The Vernier scale of the microscope reads to 0·001 cm., and each individual reading was probably accurate to this

* "Gas Journal," Vol. CLVI., p. 498.

degree. The error is very small compared with the distance between the two points; but it is appreciable so far as the after-contraction or expansion is concerned.

An examination of the figures in Table I. shows that, *without* exception, the duplicate data for the small pieces are concordant within the limits of the error of reading. In the case of the whole bricks, the majority of the readings are in agreement; but there are some instances (see Table II.) which show differences greater than the reading error, in particular those which have comparatively large contractions. These large errors are due to experimental conditions explained below.

In each experiment the bricks were arranged in the furnace in a specified manner, and it was found that the larger contraction was invariably on that side of the bricks adjacent to the burners. In these cases the bricks were refired with the opposite side adjacent to the burners. On measurement it was found that the difference between the two readings was greatly reduced. Eight of the bricks giving divergent results were refired, and six of these now gave readings agreeing within the allowable error of reading. In the cases of the other two (Table II., Nos. III. D. and IV. A.) the differences were much reduced. These figures are tabulated in Table II.

Where there were discrepancies in the "breadth" readings, the greater contraction was on that end of the brick in the centre of the furnace; the bricks being placed with the long edges parallel to the furnace sides. With this arrangement it was not possible to reverse the positions of the ends, and, therefore, in some instances the same end was fired twice in the centre. On measuring these it was found that the divergence was due to the unequal heating effect in the furnace.

In a final consideration of the experimental results the following points may be emphasized:—

(*a*) In the case of very small contractions of whole bricks, the error due to unequal firing is not apparent, as it is obscured by the measurement error involved.

(*b*) Where the contractions of whole bricks are sufficiently large to show a measurable difference due to unequal firing, this difference can be nullified by refiring as described.

(*c*) Table I., series IV., shows results which are apparently not in agreement with the generalization stated above. In this case comparatively large contractions occurred, and it was found that the results were nevertheless concordant after the first firing. Too much reliance cannot be placed on these figures, as the bricks vitrified badly, and also warped after the firing.

(*d*) In the case of silica bricks, the objection to using whole bricks is that they are liable to crack, and in many instances no readings could be taken.

(*e*) As opposed to the whole bricks, the *small pieces*, owing to the more equal firing obtained with the size of furnace available, show concordant results throughout; and while at the same time considering the greater measurement error involved (due to the smaller distance measured), they are recommended for use in carrying out the test

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THE THERMAL CONDUCTIVITY OF REFRACTORY MATERIALS AT HIGH TEMPERATURES.

By A. T. GREEN.

The problem of fuel economy in many of its varied aspects has given considerable impetus to the study of the thermal criteria of refractories. The heating efficiency of much high temperature work cannot be computed without those quantitative data which measure the fundamental thermal properties of clay products. Then, again, improvement in the technique of many industries has made it apparent that refractories must be roughly divided into two groups—*i.e.*, conductors and insulators. The gas-retort or the coke-oven wall is the more efficient the quicker the heat is transferred through it and the greater the ease with which the desired temperature is attained on the carbonizing face; while the more nearly the blast-furnace lining approaches a perfect thermal insulator the greater is the heat conservation during the smelting of iron. Clearly, then, thermal conductivity should exert considerable influence in the selection of refractories; its importance being sufficient to merit the consideration of those who scheme the essential specifications of such materials.

During the last ten years or so several investigations of the thermal conductivity of refractories have been attempted. A variety of methods has been adopted; but the results cannot be considered concordant. The reported values of the co-efficient of thermal conductivity seem to depend on the nature of the adopted method, and, consequently, a discussion of this previous work may form a criticism of the present paper.

REVIEW OF PREVIOUS WORK, TOGETHER WITH THE PRINCIPLES OF THERMAL CONDUCTIVITY.

A.—Methods depending on the use of a calorimeter.—Consider a uniform plate with parallel walls such that one face is maintained at a temperature θ_1, and the other face at a temperature θ_2. Suppose that a quantity of heat Q passing through the plate, in a time t, is necessary to maintain the two faces at the above temperatures. Then, if the thickness of the plate is x and the area is A,

$$Q = \frac{K(\theta_1 - \theta_2)\ At}{x} \qquad (1)$$

where K is an assumed constant, depending on the nature of the substance, and is known as the co-efficient of thermal conductivity, or just the "thermal conductivity" of the material. In C.G.S. units it is the number of calories transmitted from one face of a cube of edge 1 cm. to the opposite face in 1 second, when the two faces are maintained at temperatures differing by 1° C. Formula 1 has been used as the basis of almost all the work on the conductivity of refractories. Its use entails a measurement of $\frac{Q}{t}$, the heat term, which may be obtained either calorimetrically or electrically. Wologdine's (1) work was the forerunner of the "calorimetric" investigations. The object of this work was to seek a relationship between thermal conductivity and temperature, porosity, permeability to gases, and temperature of firing for a large number of French refractory products. A circular disc, 5 cm. in thickness, with bevelled edges, was used as the specimen piece. This test shape formed the top of a gas-fired muffle. Two platinum—platinum-rhodium thermo-couples were placed at distances of 5 mm. from each face, and these served to indicate the temperature of the faces themselves. Guided by experiment, the investigator assumed a linear gradient of temperature through the brick, and, by subsequent extrapolation, these two face temperatures were obtained. The factor $\frac{Q}{t}$ was measured by means of a water flow calorimeter resting on the cooler surface of the specimen. This measurement is open to much criticism. It is obvious that the cool surface of the calorimeter distorted the heat flow through the specimen from its normal directions, and since no "guard ring" was used with the object of preventing this, a serious error was introduced into the experiment. The temperature measurement can be criticised by reason of the fact that the thermal conductivity increases with temperature, and the assumption of a linear gradient of temperature cannot be maintained. All the test-pieces were specially made. This, in itself, forms an objection, since it is of particular consequence to the industrial value of the results that ordinary commercial bricks of standard size and shape should be used. A detailed criticism of the errors in Wologdine's work can be found in papers by Goerens (2), Heyn, Bauer, and Wetzel (3), and in an excellent review of the principles relating to the methods of determining the thermal conductivity of refractories by Rosin (4).

Goerens (5), seeking improvements in the technique of Wologdine's method, elaborated a "guard ring" for the flow calorimeter in order to maintain a parallel heat flow. This "guard ring" consisted of an outer jacket through which water was allowed to flow continuously. The jacket rested along the whole length of the material. The heating was obtained by a resistance wire of nickel-chrome wound round a fireclay plate, and the temperature gradient by a series of couples embedded in the material and running parallel to the hot face. Commercial bricks were used as specimens.

Dougill, Hodsman, and Cobb (6) also used a method very similar to that of Wologdine. They jacketted the calorimeter with a second calorimeter at the same tempera-

ture. One critic (7) has already suggested that since the two calorimeters were in metallic connection the existence of even a slight gradient across the metal base would adversely affect the results. The heat term $\frac{Q}{t}$ was measured by the rate of evaporation of water from the calorimeter. As in Goerens' work, commercial bricks were used. The higher temperatures (over 900° C.) were determined by means of a Holborn-Kurlbaum optical pyrometer. Considering the accuracy of the temperature measurements necessary for successful results, and the difficulties attending the use of optical pyrometers when correct absolute temperatures are required, such data must, at least, be doubted.

Boyd Dudley (8), using American standard-sized, commercial fireclay, silica, and magnesite bricks, followed the recognized principles of the calorimetric method, a flow calorimeter with a "guard ring" being used to measure the heat term. A wall of similar material forming part of a coke-fired furnace was used as the test material. The combustion in the chamber was carefully regulated with the object of obtaining an even temperature. This does not appear to have been an easy matter, although continued experience helped the investigator considerably. Thermo-couples placed in holes bored from the cold face towards the hot face to within varying distances of the hot face were used for the measurement of temperature. These thermo-couples were thus perpendicular to the isothermal planes of the brick, and, therefore, the accuracy of their measurements must have been seriously vitiated by conduction along the wire, with the consequent cooling of the junction (9).

In a paper to the Faraday Society Griffiths (10) reviewed some of the previous work, and proceeded to describe a method for the determination of the conductivity of bricks made from diatomaceous earth. The principle of the method is similar to the foregoing, but especial precautions appear to have been taken with the flow calorimeters. Perhaps the chief feature of the method was a device for obtaining an even temperature at the hot surface. A cast-iron tray contained some metal (say, tin) which was kept molten by means of an evenly distributed heating coil attached to the under surface of this tray. It was found to be an easy matter to maintain this molten metal at a constant temperature, which was regulated and measured by means of a bent, movable thermo-couple, sheathed in a quartz protecting tube. The face of the brick was held in such a position as to touch the surface of the molten metal.

An interesting attempt to measure the heat term by means of an air calorimeter has been made by Hepplewhite (11). Since but one result has so far been reported, also since the description of the apparatus is somewhat inadequate, it is not possible to form an estimate of its value.

B.—Methods in which the heat term is measured without the use of a calorimeter.—Clement and Egy (12) made a series of interesting experiments on the conductivity of fireclay material in the shape of hollow cylinders. The heating was obtained by means of a coil of nickel wire wound round a porcelain core and fixed axially to the specimen. The heat factor $\frac{Q}{t}$ was determined by noting the electrical energy dissipated in this heating coil per unit time, after the stationary state had been attained. The temperatures of the inner and outer faces of the cylinder were determined by thermo-elements. The method is, no doubt, theoretically sound, but it is very unsatisfactory from a technical point of view, since the necessity for the construction of special test-pieces introduces serious difficulties. Very few observations were made concerning the nature and composition of the material.

Examination of the results of methods A and B.—The following statements of general interest can be made from a consideration of the aforementioned investigations:

(1) In the case of silica and fireclay materials, the thermal conductivity increases with temperature.

(2) In the case of magnesite bricks, the thermal conductivity does not increase with temperature. The bulk of the evidence points to a decrease (Dougill, Hodsman, and Cobb; Goerens).

(3) The thermal conductivities of fireclay and silica materials, although varying with different materials, are, nevertheless, very similar to each other. The conductivity of magnesite is approximately four or five times that of either silica brick or firebrick (Dougill, Hodsman, and Cobb; Goerens).

(4) Comparing the results for silica bricks obtained by Dougill, Hodsman, and Cobb, and those for bricks made from diatomaceous earth by Griffiths, it seems that the latter material has but one-seventh the conductivity of silica brick, at temperatures below 800° C. Although it is not disputed that there is a great difference between these two conductivities, this large disparity is open to question.

(5) From Wologdine's work it appears that higher temperatures of firing increase the conductivity. Dougill, Hodsman, and Cobb gave two results which uphold this statement.

(6) According to Wologdine, the conductivities of carborundum and graphite are four or five times greater than those of silica and fireclay materials.

C.—Method based on Fourier's linear diffusion equation.—Heyn, Bauer, and Wetzel (13) were not satisfied with the calorimetric methods, mainly because of the uncertain nature of the effective area of heat transmission. They sought the use of a mathematical analysis as the basis of their work. Fourier's linear diffusion law made this possible. This standard equation for the linear flow of heat may be stated:—

$$\frac{d^2\theta}{dx^2} = k\frac{d\theta}{dt} \qquad (2)$$

where θ denotes temperature, x distance from a hot surface, and t time; k is a constant known as diffusivity. By using a specially constructed, electrically heated furnace, these investigators were able to heat a wall of nine bricks. Under known conditions the gradient of temperature and the rate of rise of temperature at definite distances from a hot face were measured by thermo-couples. These data formed the basis of a graphical solution of equation 2; no measurement of the heat factor being necessary. The results obtained by these experimenters were much lower than those determined by calorimetric means. The conductivity of magnesite was found to be slightly lower than that of silica and fireclay brick, and to increase with temperature. Since the theory and results of the present investigation are comparable with those of Heyn, Bauer, and Wetzel, further discussion will be left until later.

Material.	Percentage. Porosity.	Percentage Analysis.		Temp. Range.	Mean Thermal Conductivity.	Investigator(s).
		SiO_2.	Al_2O_3			
Firebrick . . .	30	66	29	200°—1000°C	0·00400	Wologdine
Firebrick . . .	29	67·5	28·2	0°—1000°C	0·00251	Goerens
Firebrick . . .	23·3	66	31	420°—1100°C	0·00330	Dougill, etc.
Clay Product . .	...	53	43	100°—1025°C	0·00262	Boyd Dudley
Clay Product . .	...	53	45	0°—1000°C	0·00211	Goerens
Fireclay Material.	..	...	...	400°—700°C	0·00265	Clement and Egy
Firebrick . . .	...	71	24	200°—1000°C	0·00117	Heyn, Bauer, and Wetzel

THEORY OF THE PRESENT INVESTIGATION.

The present work is also based on Fourier's theory of the linear diffusion of heat. Consider a wall of material in which the hot face is maintained at θ_0. Suppose that the temperature of an isothermal plane—*i.e.*, parallel to the hot face plane—at a distance x from the hot face after a time t is θ. Now, if we apply the limiting conditions that $\theta_0 = 0$ when $x = 0$ and $\theta = 0$ when $t = 0$ to equation 2 we obtain a solution :—

$$\theta = \theta_0\left(1 - \frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{2\sqrt{kt}}} e^{-B^2}\,dB\right) \qquad (3)$$

where $B = \frac{x}{2\sqrt{kt}}$

This can be stated in the form :—

$$\frac{\theta_0 - \theta}{\theta_0} = \frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{2\sqrt{kt}}} e^{-B^2}\,dB \qquad (4)$$

The probability integral—*i.e.*, the right-hand side of equation 4—can be reduced to an infinite series. However, since it has been evaluated (14) such a procedure is unnecessary for the present work. Thus, by obtaining the value of $\frac{\theta_0 - \theta}{\theta_0}$ the value of $\frac{x}{2\sqrt{kt}}$ can be computed. From this, k, the diffusivity, is easily determined. This factor is defined by Preston as "measuring the change in temperature that would be produced in a unit volume of the substance by the quantity of heat which flows in unit time through unit area of a layer of unit thickness having unit difference of temperatures between its faces." A more concrete significance is given by the equation—

Thermal conductivity = $k.c.s.$ (5),

where c is the apparent specific gravity of the material and s its specific heat. The product $c.s.$ is, thus, the heat capacity per unit volume of the material.

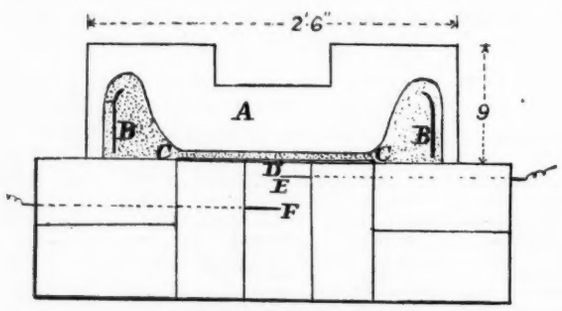
EXPERIMENTAL CONSIDERATIONS.

The theory of the experiment presupposes the following conditioning factors :—

(1) The maintenance of an even and constant temperature on the hot face from the beginning to the end of the experiment.

(2) The accurate measurement of the rate of rise of temperature for any isothermal plane at a known distance from the hot face.

Nine rectangular bricks (9 in. by 4½ in. by 2½ in.), which for practical purposes are identical in all respects—*i.e.*, size, shape, composition, and burning, &c.—are chosen. These are built to form a wall such that their lengths indicate the direction of flow of heat. Each brick is laid on a very thin layer of ground brick material, thus helping in some degree to preserve the continuity of like material. The central brick of this wall is regarded as the test material. At fixed distances from a specified face (which is known as the hot face) say, 5 cm. and 8 cm., two holes, about $\frac{1}{16}$ in. in diameter, have been drilled into this brick, parallel to the face, so as to reach the centre of the brick. Into each of these holes a platinum—platinum-rhodium thermo-couple has been placed so that it reaches the brick material at the end of the hole. In order to keep the thermo-couples in position, and, further, with the object of remedying any disturbance of the heat flow, these holes have been filled with ground brick. The thermo-couples have been taken by way of small grooves through the brick structure in a direction parallel to the hot face.



A, furnace part of refractory clay.
B B, electrodes.
C C, hot plate.
D, face thermo-couple.
E, 1st hole thermo-couple.
F, 2nd hole thermo-couple.

Fig. 1.—Cross-Section through Plane of Thermo-Couple Holes parallel to the Base of Apparatus.

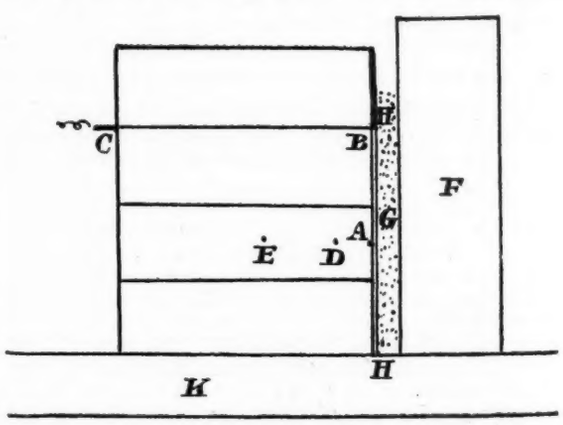
The face temperature is measured by means of a thermo-couple fixed in the centre of the hot face of the test brick. To do this effectively the thermo-couple wires are carried along very narrow grooves cut in the face of the brick; while the junction fits into the small hole made at the intersection of the grooves. The couple, which is kept in position by means of a little fire cement, is carried along the hot face, along the top of the structure, and thence to a unipivot galvanometer. A structure of firebricks (*vide* sketches) is built round the experimental wall, and the "hole" thermo-couples, after being carried through this structure, are connected by means of compensating leads to two recording galvanometers.

A bauxitic plate, somewhat larger in area than the face of the nine bricks, and placed with a clearance of about ¼ in. from this face, is used to maintain the temperature. It forms the central constricted portion of a carbon resistance furnace, which is similar in principle to the standard Hirsch refractory testing apparatus. Finely-divided graphite is used as the resistor, and iron plates, 12 in. by 5 in., which are bent in the middle to fit the furnace, serve as electrodes.

At the beginning of the experiment, in order to reach the desired face temperature as quickly as possible, the amperage is raised considerably. When the temperature is attained after approximately one hour, it is maintained constant for about nine hours at a much reduced amperage. A switch near to the furnace helps very much in this work. The temperatures of the two isothermal planes are continuously recorded; but with the object of reading all temperatures on one instrument they are taken every hour on the unipivot galvanometer which regulates the face temperature. This facilitates the checking of the couples against the melting points of standard substances—*i.e.*, tin, potassium, dichromate, common salt, copper, and potassium sulphate.

In the earlier experiments it was noted that results obtained from the first heatings were not concordant with those obtained in later heatings with the same bricks. In the case of three batches of material (two fireclay and one magnesite), the results of the first heatings were high. In two other cases (one silica, one fireclay) they were low. To obviate such discrepancies the brick face is subjected to a continued heating for over twelve hours at a temperature of 1100° C. The results obtained after this treatment agreed well. The fact that the bricks have been fired at temperatures far higher than those at which discordance is noted, is of some significance. Heyn, Bauer, and Wetzel (16) also reported phenomena similar to the above..

To check the constancy of the hot face temperatures,



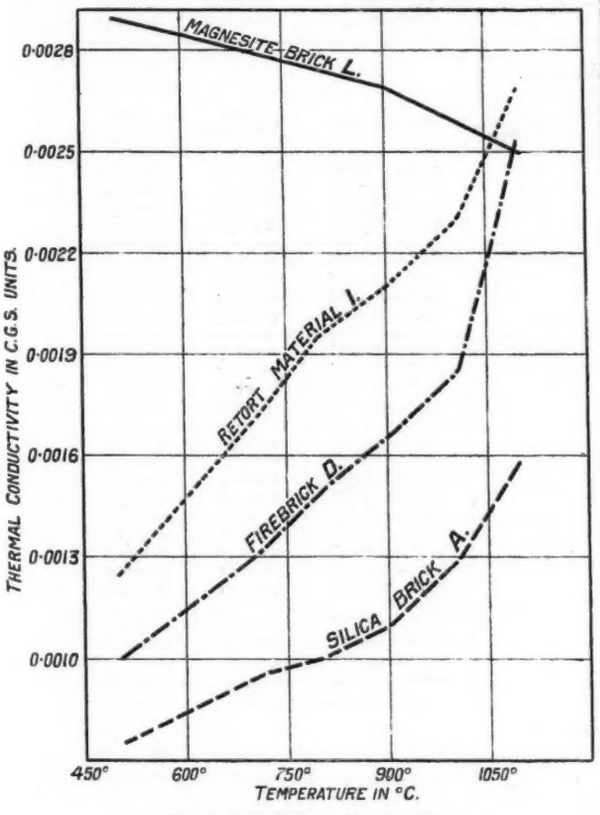
A D E, position of three thermo-couples.
A B C shows the path of the face thermo-couple.
F, furnace part.
G, graphite resister.
H H, hot plate.
K, base of apparatus.

Fig. 2.—Cross-Section perpendicular to the Plane of the Thermo-Couple Holes.

a number of experiments were conducted in which five thermo-couples were placed flush with the hot face of the specimen brick—one at each corner and one in the centre. After two hours' heating, the difference of temperature encountered was never greater than 10° C.

In the calculation of the results, the temperature obtained after a period of about nine hours is taken. Theoretically, the time factor depends upon commencing the experiment with the desired hot face temperature.

Practically, as already mentioned, such a temperature is not obtained until a period varying from 0·7 to 1·5 hours has elapsed. A correction is therefore necessary. This cannot be computed accurately, because the initial conditions are not in keeping with those set down in the Fourier's analysis. Calculations based on the theory of the experiment and the temperatures observed at the end of the initial period indicate an empirical correction amounting to about 0·3 hours when the initial heating is under one hour, and 0·4 hour when this heating is between 1 hour and 1·5 hours. This approximation cannot introduce any appreciable error into the results, since the time factor used in the calculation is about nine hours, and after such a time the rate of rise of temperature is rarely more than 10° C. per hour—*i.e.*, the time factor is measured quite as accurately as the temperature factor.



Calculation of Results.

It will be seen from a previous section that the temperature, time, and distance factors of only one isothermal face are necessary for the calculation of a result. The data obtained from the other isothermal face can be used as a check.

The following will illustrate the method of computing these results :—

Silica Brick.

Face temperature measured by thermo-couple A.
First hole " " " " " B.
Second hole " " " " " D.
Distance of first hole from hot face = 4·0 cm.
" second " " " " = 5·4 cm.
Hot face maintained at 1000° C. (galvanometer reading).
First hole temperature reached 735° C. (galvanometer reading) at the end of experiment.
Second hole temperature reached 648° C. (galvanometer reading) at the end of experiment.
Corrections make hot face temperature = 1028° C.
" " first hole " = 739° C.
" " second " " = 654° C.
Corrected time for the period of experiment = 8·8 hrs.

Considering the first isothermal face—

$$\frac{\theta_0 - \theta}{\theta_0} = \frac{2}{\sqrt{\pi}} \int_0^{\frac{x}{2\sqrt{kt}}} e^{-B^2} \, dB$$

$$\text{and } \frac{\theta_0 - \theta}{\theta_0} = 0{\cdot}2821$$

from the evaluation of the probability integral

$$\frac{x}{2\sqrt{kt}} = 0{\cdot}2556$$

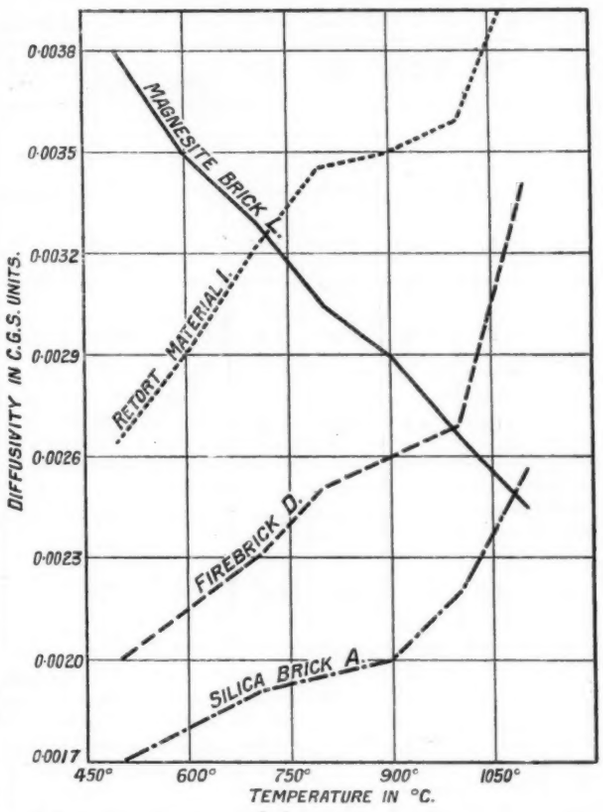
$\therefore$ k (diffusivity) = 6·960
= 0·00194 in C.G.S. units.

and since thermal conductivity = k.c.s.
" " = 0·00107.

Similarly, considering the second isothermal face—

Thermal conductivity = 0·00107.

In the calculation of the conductivity of fireclay and silica material from the diffusivity, the data of specific heat were obtained from measurements made by Bradshaw and Emery (17). They showed that the specific heat of these materials increases with temperature, which fact has been recognized in all the computations. In connection with the work of magnesite, it was found necessary to determine the specific heat of this substance at temperatures up to 1100° C. The values of this "constant" also increase with temperature, and are



higher than those of silica or fireclay material. The high specific heat and specific gravity of magnesite give a comparatively very high value for the heat capacity per unit volume of this substance.

Texture of Experimental Material.

Before proceeding to any discussion of these results, it will be as well to describe the textures of the various materials.

A$_1$, *A*$_2$, *A*$_3$, *A*$_4$.—*Silica brick.*—Texture very open. Many large and sub-angular rock fragments. Bonding of coarse and fine fairly good, although adherence of some of the grains is only fair. Abundant large fissures.

B.—Silica brick.—Exceptionally fine-grained, close texture. Major portion of material of sand size. Fragments of rock of appreciable size scarce. Those seen vary from round to sub-angular. Texture uniform throughout brick. Very appreciable porosity, but pores seem to be of even size. Friable.

RESULTS.—*Silica Material.*

Mark.	Percentage Porosity.	App. S.G.	True S.G.	Percentage Analysis. SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Temp. Range.	Mean Diffusivity.	Mean Thermal Conductivity.
A1.	24·0	1·75	2·30	95·40	0·90		1·68		586°— 816°C 655°— 921°C 739°—1028°C 827°—1138°C	0·00177 0·00186 0·00194 0·00211	0·00086 0·00097 0·00107 0·00123
A2.	24·0	1·75	2·30	95·40	0·90		1·68		518°— 816°C 572°— 921°C 654°—1028°C 732°—1138°C	0·00187 0·00190 0·00200 0·00219	0·00090 0·00096 0·00107 0·00124
A3.	22·3	1·80	2·31	95·40	0·90		1·68		486°— 703°C 637°— 906°C 714°—1008°C 798°—1114°C	0·00186 0·00202 0·00206 0·00239	0·00088 0·00106 0·00115 0·00141
A4.	22·3	1·80	2·31	95·40	0·90		1·68		410°— 703°C 541°— 906°C 605°—1008°C 658°—1114°C	0·00202 0·00217 0·00219 0·00228	0·00094 0·00110 0·00119 0·00129
B	31·3	1·51	2·20	94·02	1·78		2·64		610°— 815°C 704°— 924°C 790°—1032°C 894°—1142°C	0·00265 0·00286 0·00312 0·00345	0·00114 0·00130 0·00150 0·00177
C	20·7	1·84	2·32	93·36	2·97		2·20		661°— 903°C 733°—1005°C 829°—1114°C	0·00212 0·00229 0·00238	0·00115 0·00131 0·00145

Fireclay Material.

Mark.	Percentage Porosity.	App. S.G.	True S.G.	Percentage Analysis. SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Temp. Range.	Mean Diffusivity.	Mean Conductivity.
D.	17·3	2·03	2·46	68·38	26·12	2·50			508°— 788°C 584°— 891°C 657°— 995°C 740°—1096°C	0·00224 0·00237 0·00251 0·00278	0·00124 0·00139 0·00154 0 00187
E.	15·9	2·00	2·36	57·90	32·96				608°— 822°C 693°— 927°C 785°—1030°C 892°—1138°C	0·00211 0·00220 0·00263 0·00303	0·00119 0·00136 0·00167 0·00206
F.	24·6	1·92	2·55	67·49	27·15				498°— 786°C 568°— 890°C 650°— 994°C 733°—1098°C	0·00215 0·00227 0·00244 0·00267	0·00113 0·00124 0·00142 0·00164
G.	24·5	1·85	2·45	67·10	27·17				492°— 787°C 560°— 890°C 634°— 994°C 716°—1098°C	0·00192 0·00207 0·00215 0·00234	0·00096 0·00110 0·00117 0·00136
H.	28·2	1·88	2·62	65·70	28·47				532°— 786°C 608°— 892°C 680°— 994°C 767°—1098°C	0·00233 0·00248 0·00253 0·00276	0·00119 0·00134 0·00145 0·00168
I.	24·7	1·91	2·54	72·46	23·65				554°— 786°C 634°— 892°C 713°— 994°C 796°—1098°C	0·00308 0·00322 0·00341 0·00365	0·00162 0·00182 0·00198 0·00226

Magnesite Material.

Mark.	Percentage Porosity.	App. S.G.	True S.G.	Percentage Analysis. SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Temp. Range.	Mean Diffusivity.	Mean Therma Conductivity.
J.	20·0	2·63	3·29	...	...	1·87	5·24	81·79	509°— 703°C 586°— 806°C 647°— 909°C 717°—1012°C	0·00214 0·00204 0·00186 0·00181	0·00174 0·00174 0·00166 0·00167
K.	20·0	2·63	3·29	...	...	1·87	5·24	81·79	545°— 806°C 606°— 909°C 712°—1116°C	0·00217 0·00213 0·00171	0·00182 0·00188 0·00162
L.	24·5	2·56	3·38	...	...	2·56	4·68	87·88	510°— 690°C 572°— 786°C 644°— 890°C 708°— 991°C 766°—1097°C	0·00352 0·00314 0·00310 0·00299 0·00268	0·00285 0·00265 0·00273 0·00274 0·00255

C.—Silica brick.—Texture fairly open. Large proportion of angular rock fragments, which vary in size from ¼ in. downwards. Bonding of coarse and fine fairly good. Fine material, easily detached. Large number of fissures of appreciable size.

D.—Firebrick.—Close structure. Not much clay grog, but large proportion of angular quartz grains. Adherence very good. Very few fissures. Quartz grains very evenly graded; possibly all would pass an 8's lawn. Faces of brick not good. Very fine black cores. Appearance of many pinholes.

E.—Firebrick.—Very close structure. Abundance of fine grained rounded grog. A little larger grained grog can be detected. Adherence exceptionally good. Marked by a fair number of black cores, generally with cavities. Faces smooth, edges sharp.

Variation of Conductivity with Temperature.

Material.	Mark.	500°	600°	700°	800°	900°	1000°	1100°
Silica Brick	A	0·0007$_5$	0·0008$_5$	0·0009$_5$	0·0010	0·0011	0·0013	0·0016
,, ,, ...	B	...	0·0009$_5$	0·0011	0·0012$_5$	0·0014$_5$	0·0017	0·0020
,, ,, ...	C	...	0·0008$_5$	0·0010	0·0012	0·0013$_5$	0·0015	0·0016$_5$
Firebrick	D	0·0010	0·0011$_5$	0·0013	0·0015	0·0016$_5$	0·0018$_5$	0·0025
,, ...	E	...	0·0010	0·0012	0·0014	0·0016	0·0019$_5$	0·0024
,, ...	F	0·0010	0·0011	0·0012	0·0013$_5$	0·0015	0·0017$_5$	0·0021
Retort Material . .	G	0·0008	0·0009	0·0010$_5$	0·0012	0·0013	0·0014	0·0017$_5$
,, ,, . . .	H	0·0009$_5$	0·0011	0·0012$_5$	0·0014	0·0016	0·0017$_5$	0·0021
,, ,, . . .	I	0·0012$_5$	0·0014$_5$	0·0017	0·0019$_5$	0·0021	0·0023	0·0027
Magnesite Brick . .	J	0·0017$_5$	0·0017$_5$	0·0017	0·0017	0·0016$_5$	0·0016$_5$	0·0016
,, ,, . .	L	0·0029	0·0028$_5$	0·0028	0·0027$_5$	0·0027	0·0026	0·0025

Variation of Diffusivity with Temperature.

Material.	Mark	500°	600°	700°	800°	900°	1000°	1100°
Silica Brick	A	0·0017	0·0018	0·0019	0·0019$_5$	0·0020	0·0022	0·0025$_5$
Silica Brick	B	...	0·0024	0·0026	0·0028	0·0030	0·0033$_5$	0·0037
,, ,, ...	C	...	0·0017$_5$	0·0019$_5$	0 0022	0·0023	0·0024	0·0025$_5$
Firebrick	D	0·0020	0·0021$_5$	0·0023	0·0025	0·0026	0·0027	0·0034
,, ...	E	...	0·0019	0·0021$_5$	0·0023$_5$	0·0025	0·0029	0·0034
,, ...	F	0·0021	0·0022	0·0022$_5$	0·0023$_5$	0·0024$_5$	0·0027	0·0031
Retort Material . .	G	0·0017$_5$	0·0018$_5$	0·0020	0·0022	0·0022	0·0023	0·0026$_5$
,, ,, . .	H	0·0020$_5$	0·0022$_5$	0·0024	0·0025$_5$	0·0026$_5$	0·0027$_5$	0·0031
,, ,, . .	I	0·0026$_5$	0 0029	0·0032	0·0034$_5$	0·0035	0 0036	0·0040
Magnesite Brick . .	J	0·0023	0·0021$_5$	0·0020	0·0019	0·0017$_5$	0·0017	0·0016
,, ,, . .	L	0·0038	0·0035	0·0033	0·0030$_5$	0·0029	0·0026$_5$	0·0024$_5$

F.—Firebrick.—Very open texture. Abundance of rounded clay grog of uneven grading, some grains approximating to pebbles. Unweathered pellets detected. Adherence poor—in fact, material is very friable. Highly fissured.

G.—Retort material.—Very open texture. Very heavily grogged with medium to fine rounded material of uneven grading. Abundance of small fissures. Adherence of grog very poor. Matrix appears to have contracted away from the grog.

H.—Retort material.—Somewhat closer in texture than G. Heavily grogged with rounded material of slightly more even grading than G. Adherence as a whole fairly good, although some grains are easily detached. Some fissures. Very white colour with well-defined skin.

I.—Retort material.—Very close in texture. Abundant grog which, tending to be rounded, is evenly graded. Possibly some quartz fragments. Black cores present, but scarce. Tendency towards layering. Fissures, present but scarce, are parallel to outside faces. Superficial skin. Signs of possible reduction towards end of fire.

J and K.—Magnesite bricks.—Two bricks of the same batch. Texture very close.

L.—Magnesite brick.—Texture not so close as in J and K.

Discussion of the Results.

A_1, A_2, A_3, A_4, represent the results obtained from two different specimens of a well-known brand of silica bricks. A_1 and A_2 represent the results from two isothermal planes in the one brick; A_3 and A_4 two isothermal planes in the other brick. A_1 is 4·0 cm., A_2 5·4 cm. respectively from the hot face of No. 1 specimen, A_3 and A_4 4·3 and 6·4 cm. respectively from the hot face of No. 2 specimen. In the measurement of the temperatures of No. 1 specimen a different set of thermo-couples from those used in No. 2 specimen gave the temperature readings. The results indicate in some degree the error of experiment. It cannot be assumed, however, that the material factor in any one series is the same. This factor has been known to vary quite appreciably within the same brick. It should be mentioned that in every series of experiments reported in this paper the results obtained from the second isothermal face are slightly higher than those obtained from the first. An explanation of this may lie in the disturbing effect of the first hole, but nothing definite has been settled on this point.

The results are generally much lower than those obtained by "calorimetric" experiments, but they agree well with those obtained by Heyn, Bauer, and Wetzel, except in the case of magnesite. These latter investigators showed magnesite to possess a thermal conductivity which was slightly lower than that of firebrick, and which increased with temperature. Dougill, Hodsman, and Cobb, Goerens, and Boyd Dudley showed that, besides being four or five times greater than that of firebrick, the thermal conductivity of magnesite decreased with temperature. The present investigations indicate that magnesite has in general a greater conductivity than firebrick at temperatures below 1000° C., but it decreases with temperature. Much difficulty attached itself to the magnesite measurements, since they seemed to vary considerably with the nature and amount of the heating of the hot face. It was only after a considerable heating that concordant results were obtained. The initial experiments on the material J showed a conductivity 70 per cent. greater than the reported value. L, however, was not so difficult, and gave the reported results after twelve hours' soaking.

It has been suggested that there is a relationship between thermal conductivity and porosity. While such a statement cannot be refuted (for, in part, it must be true), its limitations should be frankly recognized. In so far as the pore spaces act as insulators, thus impeding the passage of heat, they have an influence on thermal conductivity.

The term porosity is used to indicate a measure of the

pore spaces, which, naturally, vary in size from easily perceptible fissures to microscopic holes. The property of "pore space" insulation depends upon many factors, some interrelated, including temperature and the disposition, size, and shape of the pore spaces.

The measurement of percentage porosity does not include any knowledge of these latter factors, and, consequently, a quantitative relationship between percentage porosity and thermal conductivity is not to be anticipated. However, our results seem to point to some connection between texture and conductivity. The silica bricks A and B are readily comparable in this respect. The fine-grained, close-textured B has a far greater conductivity than A, which possesses a coarser, more open structure.

Then, again, a comparison of the results for fireclay materials indicates the possibility of this inference. I, D, and E have greater conductivities than F, G, and H; I, which is the closest-textured material being well to the fore. It might be argued that the material of closer texture offers a more continuous passage for the heat along the solid matter, thus eliminating to some degree the necessity for radiation jumps or tortuous paths. Experiments are now in progress in which an effort is being made to define a relationship between texture and thermal conductivity.

In the case of practically all the silica and fireclay materials examined, when the hot face is at 1100° C. there has been noted a greater increase in conductivity than is consistent with a "straight line" relationship between conductivity and temperature. While the probability of such an observation being due to some inherent property or properties of the solid material is maintained, the effect of pore spaces at the higher temperatures cannot be ignored. Dr. Mellor (18) has already suggested that the radiation across the pore spaces at high temperatures is likely to be comparable with the conduction through the solid material. Dougill, Hodsman, and Cobb (19), while not refuting the principle upon which Mellor's deduction was based, have given a calculation indicating that the temperature at which the rate of radiation of heat across a pore space of 0·01 cm. is equal to the rate of conduction across a similar width of solid material, is over 3600° C. Such a temperature is well above the fusion point of the material, and, consequently, these investigators conclude that at the ordinary temperatures obtaining in industrial practice the insulating properties of the pore spaces are always maintained. Considering the conductivity results reported in this paper, which are much lower than those given by Dougill, Hodsman, and Cobb, we may be led to believe that some of the pore spaces at high temperatures (1400° to 1500° C.) lose their insulating properties, and even at a temperature of 1100° C. have the capacity for transmitting heat at rates comparable with the solid matter. Following the argument of the aforementioned investigators, consider the transference of heat across the parallel-faced section (material of width d) by conduction and the transmission by radiation across a similar shaped air space. Suppose the two faces of the section in each case to be at θ_1 and θ_2 then the quantity of heat transmitted by conduction is

$$Q_1 = \frac{k\ (\theta_1 - \theta_2)}{d} \text{ calories per sq. cm. per sec.}$$

The Stefan-Boltzmann equation for radiation is

$$Q_2 = \sigma\ (\theta_1^4 - \theta_2^4) \text{ calories per sec.}$$

Where σ is the radiation constant.

Suppose that $Q_1 = \tau\ Q_2$,

then $$\frac{k\ (\theta_1 - \theta_2)}{d} = \tau\ \sigma\ (\theta_1^4 - \theta_2^4)$$

when θ_1 and θ_2 are almost equal

$$\tau = \frac{2\ k \times 10^{11}}{d\ \theta^3}$$

Since $$\sigma = 1{\cdot}28 \times 10^{-12}.$$

Now considering the case in which we have a temperature of 1030° C., that is, 1300° A, d = 0·05 cm. and k = 0·0015

$$\tau = 2{\cdot}88$$

that is, the rate of heat transmission by conduction across the solid material is 2·88 times that by radiation across the pore spaces.

When θ = 1130° C.—that is, 1400° A—and d = 0·05 cm. and k = 0·0015

$$\tau = 2{\cdot}1.$$

Taking another case

$$\theta = 1030°\text{ C.}, d = 0{\cdot}01\text{ cm., and } k = 0{\cdot}0020$$

$$\tau = 18{\cdot}2.$$

While admitting that the value of d taken is probably greater than the average pore space, experience shows that there is an appreciable amount of such space—*i.e.*, fissures and pinholes in many commercial bricks. The conclusion gained from the calculations with the results quoted in the paper is that the pore spaces at high temperature have not the great insulating capacity accorded them by some previous investigators.

The conception of diffusivity has a very particular significance in those heating systems, in which temperature is of more importance than total heat—*i.e.*, the coke-oven and the gas-retort. In the C.G.S. units used in this paper the diffusivity may be said to express the rise in temperature produced in 1 c.c. of the substance by 1 calorie in 1 second, through 1 sq. cm. of a layer 1 cm. thick, having a temperature difference of 1° C. between its faces. This definition indicates that diffusivity measures the rate of the rise of temperature produced in a material. It is instructive to compare the results of the silica material B and the fireclay material F. The thermal conductivities are very comparable; but the diffusivity of B is far greater than F. This may be interpreted to mean that, other factors being the same, material B would be far more effective in a coke-oven than material F. Material I is of particular interest, because of its very high diffusivity and thermal conductivity. The results of our experiments which, of course, are directly concerned with the measurement of diffusivity, show this factor to vary with temperature in a manner similar to that of thermal conductivity (*vide* graphs).

It is suggested that, in the carbonizing industries, the measurement of diffusivity would form a satisfactory criterion of the thermal efficiency of the material; while, in that type of furnace work where insulation is wholly desirable, the measurement of thermal conductivity would be more satisfactory.

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(18) MELLOR; Journal Gas Lighting, March 10, 1914.
(19) DOUGILL, HODSMAN, AND COBB; *vide supra*.

Mr. A. E. BROADBERRY (Tottenham), in introducing the report of the Committee, said: As Chairman of the Refractory Materials Research Committee, it is my duty and pleasure to introduce the report. In doing so, I have to express considerable regret that the amount of work performed is not nearly so extensive as I would have liked to see. The cause of this is directly connected with what I reported to the Institution meeting last October—viz., that the British Refractory Research Committee, formed under the auspices of the Department of Scientific and Industrial Research, who have taken over the actual research work from our Committee, have been greatly handicapped by lack of funds. The tide now has turned for them, however; and the position can be best described in the words of their own report, dated May 4.

BRITISH REFRACTORIES RESEARCH ASSOCIATION.

On the formation of the Association, an agreement was entered into with the Scientific and Industrial Research Department, under which the Association undertook to raise a minimum annual subscription of £2500 for a period of five years, and the Department agreed to make an annual grant to the Association of a similar amount. This would have ensured an annual income of at least £5000 for research work.

On account of unfavourable industrial conditions which have existed practically since the inception of the Association, the total income during the period in question was less than anticipated, and amounted to £1780 19s., to which falls to be added a sum of £1778 19s. received from the Department, making the total income £3559 18s.

The want of necessary funds has hampered the work of the Association, and prevented the programme of research being fully carried out. It was an express condition of the Department that, if the income of the Association raised from its members in any one year was less than £2500, the Government grant might be modified or withheld. The income for the period to June 30, 1921, having fallen short of the guaranteed sum, the Department withheld payment of the grant for the current year, 1921-22. This caused great inconvenience, and brought about a crisis in the affairs of the Association.

Arrangements have now been made with the Department whereby a number of members of the Council have undertaken to guarantee jointly and severally to be responsible for the raising of a minimum of £2500 per annum for the three years ending June 30, 1925; and the Department will contribute an equal amount. The grant in arrear has also been received. This will enable the research work to be satisfactorily and efficiently carried on.

Now that the Association is in funds, it is to be hoped that some effective work will be forthcoming.

In the meantime, however, your own Committee have not been idle, as will be seen from the report, which deals generally with what has been done in the revision of the specification; but before I speak of revisions which the Committee have made, it is important that I should say something of what they have avoided. I refer to the subject of testing samples for refractoriness under load. We all know that in actual use in the hottest part of the retort-setting the materials are called upon to stand-up to their work under very considerable loads. This is not only because of the superimposed weight, but also because of the expansion in a position which is absolutely cribbed, cabined, and confined. Therefore, to meet such working conditions, the specification test should preferably be made under similar conditions, if we could reproduce them exactly for the purpose; but this we cannot do. A small test-piece at the right temperature would behave far differently from a huge and massive wall, stayed and supported by the retorts and the division walls.

Therefore, although we know full well that the behaviour under load differs far from our test conditions, we feel that in the present state of knowledge no test under load can be safely adopted. To provide for the difference between test and working conditions, Seger cones specified for ascertaining the heat during the tests are of higher melting-points than the temperatures the materials will be called upon to stand under working conditions. We have, however, requested the British Refractory Research Association to make arrangements as soon as possible to conduct some further investigations into the question of tests under load; and perhaps later, and with better knowledge, we may be able to adopt some method of testing which will come nearer the actual working conditions. Meantime, however, we had to go on with the revision; and a short description of what we have done so far is included in the report. The work is not complete; and there are other points to which the Committee must give attention before the revision is complete. Any suggestions which members care to put forward will be heartily welcomed.

In the meantime the British Engineering Standards Association are casting their eyes longingly towards our work, and are anxious to adopt it as their own. This should naturally be regarded by us as a great compliment. Our specification would be adopted as the British Engineering Standard, and would be used by the Association as theirs, with a due acknowledgment of our merit in preparing it. Presumably, however, our research will go on; and in the course of time probably a further revision of the specification will be required as a result of further research. What will be the position then? Shall we have full credit, and be allowed to amend the specification with similar acknowledgment, or shall we have to ask permission of the British Engineering Standards Association before we are allowed to make improvements to our own work? The Council, no doubt, will carefully consider the interests of the Institution in deciding how to deal with the Association's request.

Attached to the report there are two papers—one by Miss D. A. Jones on "Standardization of the After-Contraction Test." Although this is the first time this paper has appeared officially in the report of the Committee, it was published by permission of the Committee in the "GAS JOURNAL" of Nov. 16 last year. The investigations recorded were of great use to the Committee in the revision of the specification. They show the extreme difficulty of accuracy in taking measurements of after-contraction on materials of which the ingredients themselves alter in the process of heating to produce the contraction. They further show the impossibility of testing full-sized bricks, because they could not be equally heated in all parts in an ordinary testing furnace, and the consequent imperative need to confine the test pieces to small dimensions.

The paper by Mr. A. T. Green points out the importance of the accurate testing of conductivity of refractory materials at high temperatures. This we readily realize, and admit. We are aware that conductivity is good or bad according to the use to which the materials are put. For instance, we want high conductivity in the walls of our retorts themselves for the transmission of the heat through them to the charge of coal, in order to secure rapid carbonization. On the other hand, we want low conductivity in the face and division walls to avoid loss of heat by radiation. Mr. Green has discovered faults and inaccuracies in all former methods of testing; and the work he describes aims at eliminating these faults and inaccuracies, and at improving the recognized methods of testing. The paper is very interesting to those who are likely to be making such tests; but these are more often found in technical colleges than in gas-works, and it is hoped that during this next year work of a more practical nature will form the subject of a paper more within the scope of our Institution. However, there may be some members who have carried out tests on conductivity who can better grasp the niceties of the improvements on Fourier's methods than I can personally; and their remarks will be welcomed. I have nothing further to say in introducing the report.

Discussion.

The PRESIDENT: We are very much obliged to Mr. Broadberry for introducing the report.

Dr. HARKER: The Committee went very carefully into the question the Chairman has just spoken of—as to whether the time had arrived for the revision of the specification for the adoption of tests under load, in the place of the old method, which up to now has served its purpose fairly well. As members will understand, the test under load has already been adopted by a number of Institutions which undertake systematic investigation of refractories. In America, two or three bodies apply the test under load; but I think that the Committee have taken the right course in saying that for the time being there is no disadvantage in postponing their decision until we know a little more about what exactly happens in testing refractories under load.

Prof. J. W. COBB: Though I am a member of this Committee, I am sorry to say that I have not been able to attend any of the meetings; and I put forward my criticisms with a certain amount of diffidence on that account. I have, however, been very much interested in the work the Committee have been carrying out in various directions, and in reading the papers by Miss Jones and Mr. Green, in which some of the work is described. The Committee have apparently felt dissatisfied with the wording of their specification for refractoriness; and I am not surprised. To say that a piece of the material shall show no signs of fusion when heated to a certain temperature, is to all intents and purposes meaningless; and even the modification in wording proposed now does not seem to me to remove the difficulty, though it lessens it to some extent. It still remains a matter of personal opinion as to when the angular edges of the test-piece can be said to have "begun to lose their angularity." In my own testing, I always prefer to report the material as being equal in infusibility to Cone 28 or 30, or whatever it may be. If the test-piece is shaped approximately to pyramid form and size—which in most cases offers no difficulty—the determinations against standard cones can be made readily, and the material can be certified accordingly. Specification in that case would take the form: "Test-pieces shall not be more fusible than Cone 30," or whatever it may be. This form was adopted some years ago by the Society of Glass Technologists. The after-contraction test is one of great importance; and the measurement between lines marked on the test-piece, in my experience, gives better results than the measurement between prepared faces. My impression is that the chief thing the Committee have to guard against in this test is giving a false impression of the accuracy with which any such

test can be carried out and interpreted. It is not entirely a matter of the linear measurement offering difficulty; but there are disturbances arising from small cracks and curvatures which make it inadvisable to claim any high degree of accuracy in the result.

I was perhaps most particularly interested in the paper by Mr. Green on "The Thermal Conductivity of Refractory Materials at High Temperatures," because in it reference was made at some length to work carried out in our laboratories at Leeds, and reported some time ago in a paper by Mr. Dougill, Mr. Hodsman, and myself. I should prefer to re-state what we did and said in terms rather different from those Mr. Green has employed, in order to remove, so far as I can, an undesirable obscurity. In March, 1914, Dr. Mellor published a very interesting and suggestive calculation he had made, which led to the following conclusion: "Unless something has been overlooked, *it is therefore inferred that a high porosity favours the passage of heat through the walls of a gas-retort at temperatures exceeding dull redness.*" The italics used in publication were justified by the importance of this conclusion to all manufacturers and users of refractory materials, if the conclusion itself had been justified. Something, however, which it was quite easy to overlook had been overlooked, which altered the whole situation. The calculation depended upon the interesting point that, as the temperature rises, the rate of transmission of heat across pores by radiation increases very much more rapidly than the transmission of heat by conduction through the intervening solid material. At a certain temperature, the two will be equal, and the heat-insulating effect of pores will disappear. Breakdown at redness would occur. Applying Dr. Mellor's own method of calculation (for which we can claim no credit or responsibility), this breakdown will occur at redness if the pores are 1 cm. across—assuming that holes of such dimensions can be called pores—but with pores of anything like the average dimensions occurring in an ordinary piece of refractory material, this critical point will not be reached until a very high temperature has been attained. Now this size of 1 cm. for the pores is an implied assumption in Dr. Mellor's original calculation. It led to a wrong result, which may have been widely accepted. I notice that it was quoted by Mr. Rhead in an address on "Refractory Materials" in Birmingham lately. It should be clearly understood that there is no sound theoretical reason for assuming that a high porosity favours the passage of heat through the walls of a gas-retort at temperatures exceeding a dull redness; and it is a pity that such a doctrine should continue to be preached. It has never been supported by any practical evidence; and the experimental results which we have obtained since at Leeds would indicate the contrary—that at ordinary temperatures of use a high porosity hinders the passage of heat through the walls of a gas-retort.

Mr. Green in his paper withdraws from the original position in mentioning now a temperature of 1100° C.—*i.e.*, a yellow heat—at which the pores come to have the capacity for transmitting heat at rates comparable with the solid matter; but that is a half-hearted statement, as can be seen by reading the calculation which follows, and on which it is based. Mr. Green's conclusion is that the pore spaces at high temperature have not the great insulating capacity accorded them by some previous investigators; but he omits to say that his own calculations confirm ours, in contradicting entirely the idea that the insulating capacity breaks down at temperatures above dull redness. In view of the importance of the subject in practice to members of the Institution, this should be clearly stated and understood.

Mr. J. P. LEATHER (Burnley): The method of determining conductivity which Mr. Green has adopted—at least, the experimental portion—is of considerable interest to me, inasmuch as I endeavoured, a number of years ago, to determine the conductivity of firebrick. The only thing I have to say is that the time that is required for work of this character is a justification for having someone to conduct research for us. The time required for the management of a gas undertaking does not leave us members of the Institution generally sufficient leisure to undertake these experiments; but I endeavoured to ascertain the conductivity of firebrick very much on the lines of these experiments of Mr. Green's—that is to say, as regards using full-size bricks, having thermo-couples arranged transversely to the flow of heat and at different points. I had, I think, 5 or 6 thermo-couples in the length of a 9-in. brick, and the only reason I was not able to complete my experiments, so as to give publicity to them, was the lack of time, because the time that is required to heat-up a wall of bricks 9 in. thick until the temperature gradient has become constant is very considerable. I did not have an electric furnace for my experiments, but was heating by gas; and there was a very large consumption of gas going on for days to get anything like a constant condition. It is easy to use a number of thermo-couples if you adopt some such method as I had. I determined the temperature by potentiometer rather than by galvanometer. I adopted the calorimeter method for determining the actual conductivity; whereas the method here adopted, which seems to me to depend on the specific heat of the firebrick at different temperatures, does not appear to be so perfectly reliable. I may be wrong in that. The paper is certainly an interesting one to me, and I shall study it carefully when I have more time.

Mr. T. F. E. RHEAD: In connection with Prof. Cobb's definition of signs of fusion—"the definition of signs of fusion shall not be less than cone so-and-so"—the assumption is, I presume, that the cone of refractory material shall bend in a somewhat similar manner to the Seger cone. If this is so, it calls for extremely careful grinding of the test pieces if consistent results are to be obtained with the same material. The bending of a cone partakes somewhat of the nature of a load test. The size of the grog has an important bearing on the bending of a cone of material. I would further ask Prof. Cobb how he would deal with a material in which the matrix runs out, although the cone keeps its original shape.

Mr. BROADBERRY: I do not think I have anything to add to the discussion. We are very grateful to Dr. Harker, Prof. Cobb, and the other speakers for the very useful remarks they have made; and I hope they will be an incentive to more definite work during the current year.

SOME GAS BURNERS AND A MORAL.

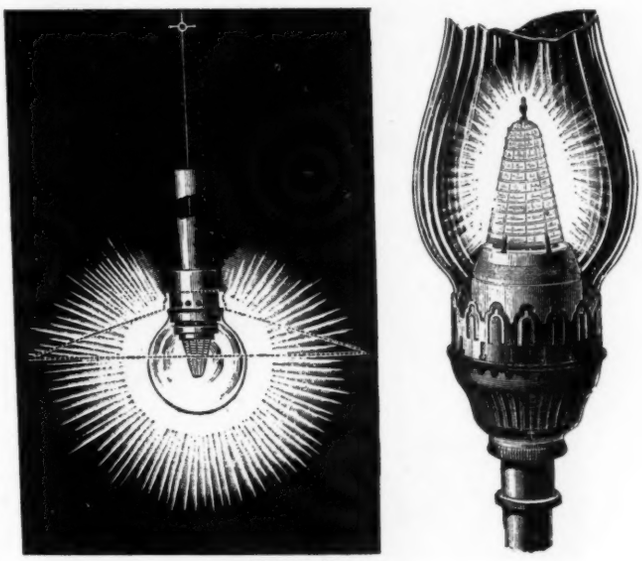
By CHARLES CARPENTER, D.Sc., M.Inst C.E.

The division of gas-burners into the two classes of self-luminous and non-luminous can be made much more sharply than the placing in similar categories of the gaseous potential by which they are, so to speak, put to work. Although the respective principles involved are very simple, their application covers an immensely greater field than could be considered within the limits of a paper of this kind, and for this reason therefore it is proposed to refer only to those which are utilized for the purpose of producing light. The basis of nearly all of them is a pin-hole in a pipe.

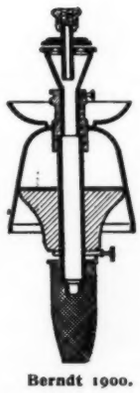
In the opening days of gas lighting groups were constructed of these jets and their bunches called cockspurs or cockscombs according to the numbers contained. Only a few years later a further arrangement of the jets was made, two being combined angularly and made to impinge against each other or placed so close together that they gave a continuous sheet of flame. The names then given of batswing and fishtail have continued to this day—over a century after their invention—when millions of them are in use. In the development of their efficiency the work of William Sugg and George Bray stands out prominently. It seems to be overlooked to-day how greatly the development of gas for lighting purposes was helped by the fact that what were practically standard burners of good quality were available all over the kingdom at the cost of a few pence each. Gas undertakings gave these away in large quantities, and their officials carried about with them, in their visits to consumers, supplies applicable on the spot to the improvement of the consumers' necessities or the satisfying of their requirements. About fifty years ago Sugg brought out his world-known Christiania burner, one of the first successful attempts to combine pleasing design with efficiency. The latter result was largely due to the attachment to the burner of an efficient form of regulator by which the gas delivery through it was kept constant at a rate best suited to the jet and the conditions required by the surrounding glass protector. But he also brought into his business the fruits of an artistic temperament, ripened on foreign soil, which permeated in greater or less degree all he undertook. The industry to-day misses him and the work in which he delighted. The previous use of governors had in the main been confined to public street lamps, since they were supplied under contract as regards gas consumption. Simpler devices were later on applied by Sugg to the batswing burner in general use, and their efficiency was an important factor in the decision reached by Parliament in 1900 when the South Metropolitan Gas Company obtained an Act by which it was enabled to supply straight coal gas without extraneous enrichment.

Simultaneous with the development of the flat flame burner was that of the Argand type in which the combustion of gas was substituted for that of oil soon after its distribution on a practical scale. Many years later this form of burner was utilized in the early attempts at recuperation of Frankland and Bowditch, afterwards ingeniously developed by Wigham for lighthouse purposes. In the late seventies Siemens introduced his epoch-making regenerative system applied to the multi-tubular upright, and afterwards the inverted, Argand. Conspicuous workers in this same field were Clark, Bower, Grimston, Wenham, Sugg, and many others. Their productions were in very general use until they were displaced by the Auer device which, as all the world knows, utilizes the burner invented by Bunsen and which goes by his name. Hogg, probably the first to use in connection with it a metallic gauze for the purpose of obtaining luminosity, was followed by Lewis, and later by Clamond, who also applied his magnesia basket to inverted burners, and was thus able to utilize the heat of the combustion products. The "baskets" gave a soft pleasing light but proved too fragile for ordinary use. The development of the mantle as a source of light followed quickly the introduction of the first "C" type incandescent burner in 1887. It is an interesting sidelight on the imagination of the gas engineers of that day to remember that their almost universal attitude was condemnatory. Ten years later Kent proposed the use of an inverted mantle suspended from a swan-neck, and three years afterwards Bernt and Cervenka patented their burner which is the prototype of one in wide use to-day. It is interesting to compare this pattern with Ahrendt's model inspired by very opposite ideas on the applicability of the recuperation principle. The addition of an incandescing structure to a bunsen flame was not confined to the gauze or refractory basket of Lewis and his followers. As far back as 1881 Harmen suggested heating a series of superposed rare metal wires, followed by Fahnehjelm with a depending "comb" of extended refractory earth mixtures. De Mare worked on the same idea of using refractory "plumes," as well as De Leary who suspended "tassels" over bunsen jets. In later years the proposal has been revived by René Laigle, whose invention went by the name of the "Hella Bushlight." Some interesting points about this burner have not so far been explained.

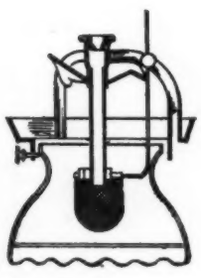
The most important recent developments of the incandescent system of gas lighting have been in the use of more efficient mixtures. This work also may be said to have commenced with Lewis, followed by Bandsept and Denayrouze. The latter applied both driven and automatic fans to obtain more intimate mixture of gas and air, and his proposals formed the foundation for many subsequent developments of "intensive" incandescent gas-lighting, of which the most important examples to-day are those installed by The Gas Light and Coke Company in the Cities of London and Westminster.



Clamon Burners.



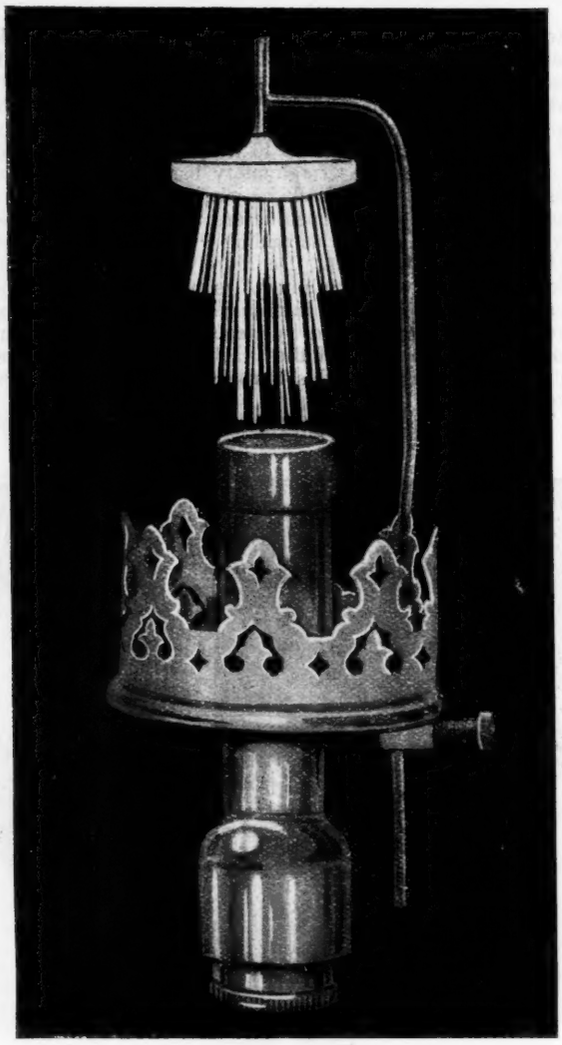
Berndt 1900.



Ahrendt 1903.

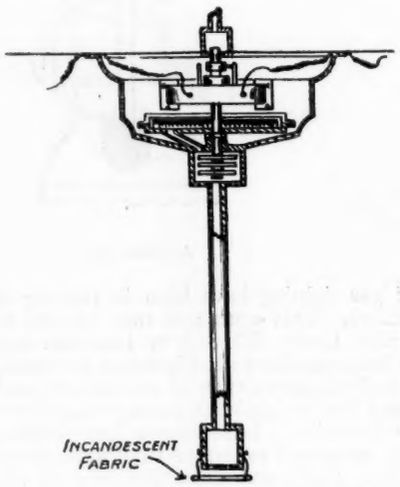
Now it is quite beyond the scope of this paper to give a history of gas burners, and therefore of gas lighting. Those who are interested in the matter will, it is hoped, be able to find an interesting compilation in the pages of a

work in course of preparation at Old Kent Road. All that is aimed at now is to give a rapid and cursory glance at the development of gas burners throughout the last century, and their use at the beginning of the present one. Superficial though the glance has been, one fact stands out predominantly, namely, that the development has not been made by those with whom it is customary to associate the profession of gas engineering. Practically the whole of the invention and research necessary, indeed vital, to the gas industry has been carried out in independent workshops and laboratories. The other important fact which investigation shows is that no matters essential to the gas consumer of to-day are the monopoly of patents. Many interesting and useful modifications of various kinds are indeed so protected, but they are rather in the nature of finishing touches than master devices. One effect of this is that instead of a high standard of certain gas burning appliances being maintained by certain manufacturing organizations who had too high a character to risk losing —I need only give as examples the Sugg, Bray, and Welsbach Companies — much of the production and marketing of these essentials has passed into the hands of "shoddy" manufacturers and unscrupulous agents, who have no more interest in the article they make or sell than the profit it brings them in.

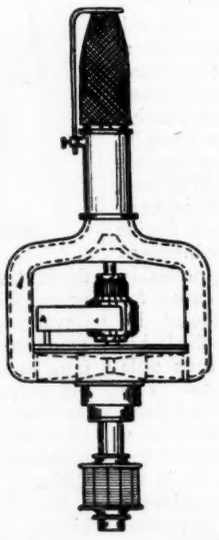


Hella Bushlight.

An outsider would be very likely to propose the query, "But surely the collective gas industry, of the national importance of which we are so often reminded by the public press, has formulated certain standards with which the makers of fittings, burners, glassware, and mantles, should be expected to conform?" The answer is, of course, that it does nothing of the kind. It leaves the market to be flooded with cheap glassware, inefficient mantles, wasteful burners, and unsafe gas fittings without raising a finger to protect the public. It has not even laid down the conditions requisite to ensure that the simplest of all its appliances, a common gas tap, continues the fool-proof device it was designed to be. It has never standardized the sizes of burners, nor those of mantles. Still less has it prepared and published specifications with which these should both comply. It has devised no test for gas fittings, with the result that "shoddy" makes which should be relegated to the scrap heap or the melting pot are distributed far and wide all over the country. These "cheap and nasty" burners and fittings constitute a menace, the seriousness of which is hardly realized. In construction they are bad, and in use they are inefficient and unsatisfactory. In the appendix, results are given of tests of some of these "shoddy" burners and fittings. The stability of the business of gas undertakings is seriously imperilled by the dissemination of such rubbish, and the time has passed when it could be treated with indifference. But gas companies themselves send out thousands of appliances which they leave either to their peripatetic fitters or even to the consumers themselves to "tune up" on their premises. Surely they should satisfy themselves that every appliance passing through their hands should be of a kind properly to satisfy the requirements of the users. Nearly thirty years ago one of the most cultured men who has occupied the presidential chair of this important industry uttered these words of warning: "There was a tendency amongst gas engineers to concentrate attention upon the larger matters of their profession and to overlook



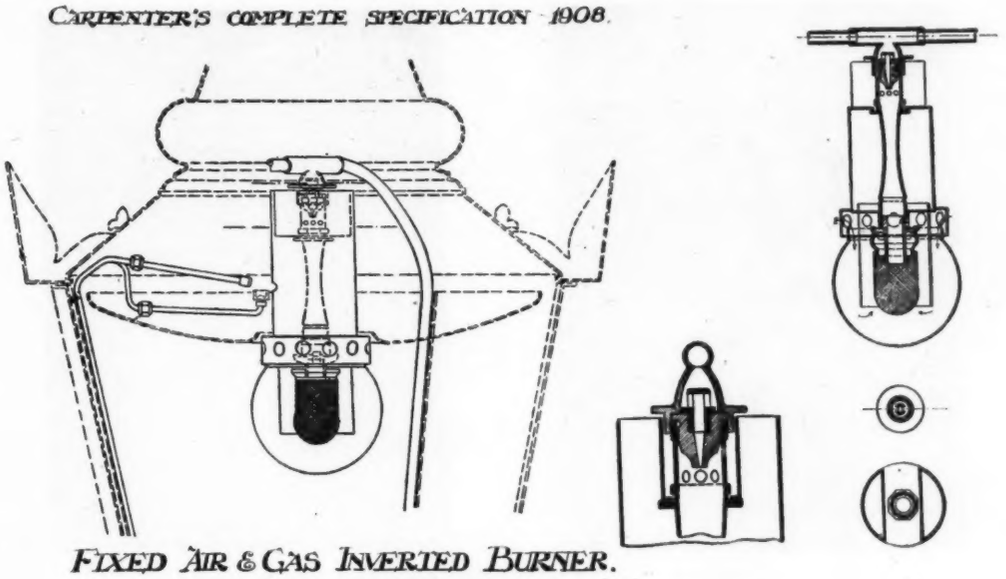
DENAYROUZE 1894
INVERTED TYPE.



DENAYROUZE 1895

BANDSEPT 1895.

CARPENTER'S COMPLETE SPECIFICATION 1908.



FIXED AIR & GAS INVERTED BURNER.
FOR STREET LIGHTING.

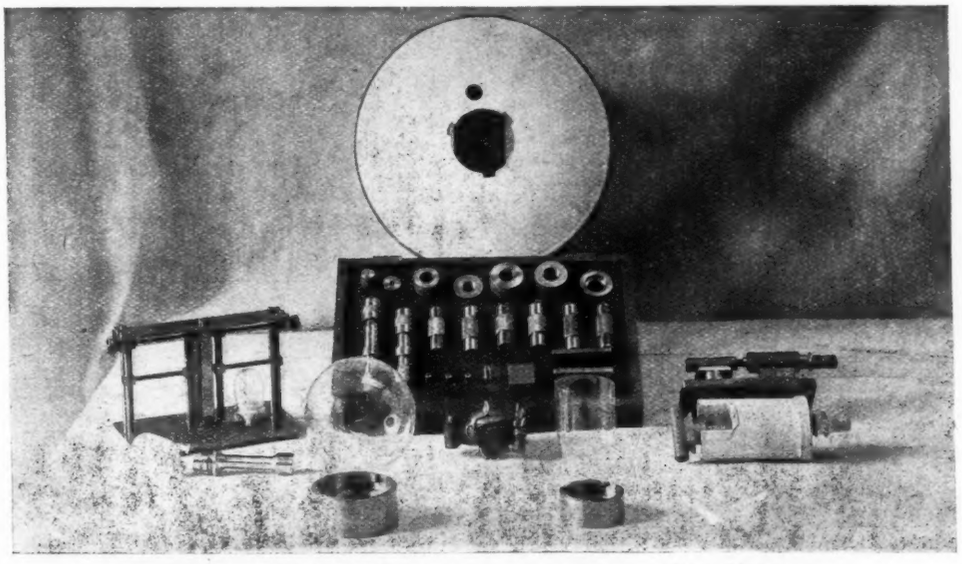
the small ones, but it was often the latter which largely determined success or failure of their business. . . . . Gas engineers might feel proud when they regarded a large gasholder containing 12 or 13 million feet of gas, but if they were to look more carefully into the smaller matters, such as gas burner construction, and the suitability of gas appliances for consumers' use, they would find that these were of vital importance to the success of their business."

It is now over fourteen years since the South Metropolitan Gas Company directed attention to the possibility of generally supplying consumers with gas lighting burners constructed on what was then considered to be a Utopian principle. The idea of fixed proportions for "gas and air" as applied to incandescent gas burners, particularly of the inverted type, was believed by most gas men to be impracticable, but the need for this system had been repeatedly emphasized by the Distribution Department. From the introduction of the upright incandescent system in the street lamps of South London in the year 1900, the principle of fixed air and gas as applied to gas burners has given complete satisfaction, and when in 1909 the adoption of the inverted system was contemplated it was determined to apply the same principle which had proved right in the case of the upright burners. Many thousands of inverted burners made on this plan have been in use in South London for the past thirteen years.

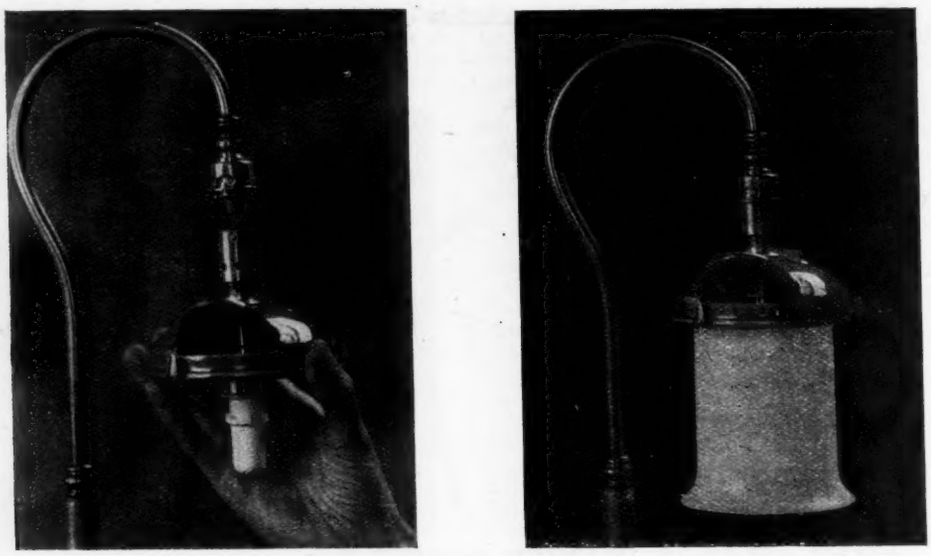
The knowledge and experience of the Gas Sales Department concerning the abuse to which regulating devices were subjected at the hands of private consumers could not be disregarded, and the conclusion was arrived at, that burners with "fixed air and gas" should be provided for the use of the consumers of the Company's gas. But if a system of this kind was to be a success in every-day practice, it was realized that it would be necessary not only to provide standard gas burners, but also to supply a gas of uniform quality which should be kept within well-defined limits as to its physical and chemical properties.

It is a long story of research and works re-organization of methods and practice, but ways and means were devised which made possible the realization of the Company's ideal. Standard gas burners had also to be evolved experimentally, and the departments concerned were instructed to collaborate with the object of producing appliances which should be suitable for use with the Company's gas. This also involved a great deal of research, but the problem was solved, and it is satisfactory that for many years the system of "fixed air and gas" has been in successful operation in the area supplied south of the Thames.

The only possible objection which might be raised is that, where exceptionally high gas pressure is experienced, economical usage depends upon the operation of the tap at the fitting. This is true, but such adjustment is of the simplest possible nature, and in practice the objection will



"METRO" INVERTED STREET LIGHTING BURNER, IN USE SINCE 1909.
GAUGES FOR CHECKING AND TESTING ARE SHOWN.



"METRO" INVERTED BURNER.

be found to be pointless. In special instances the employment of a small service governor will be found to meet all requirements, but in the majority of cases the operation of the tap is the simplest and most satisfactory arrangement.

Long experience of the matter has proved that burners without gas or air adjustment other than that provided by the tap can be designed which will afford an efficiency deviating little from a pre-ascertained value, provided the calorific value of the gas does not depart from the declared standard by more than 25 B.Th.U. This principle is now basic in the Company's policy, and the manufacture of standard gas and standard gas burners is now a daily routine. It will be understood that the re-arrangement of a large district of supply and the displacement of apparatus which is considered unsuitable is a long process, but the "District" is now largely equipped with appliances which conform to the requirements so definitely laid down.

The work of the Company in this connection has resolved itself into—

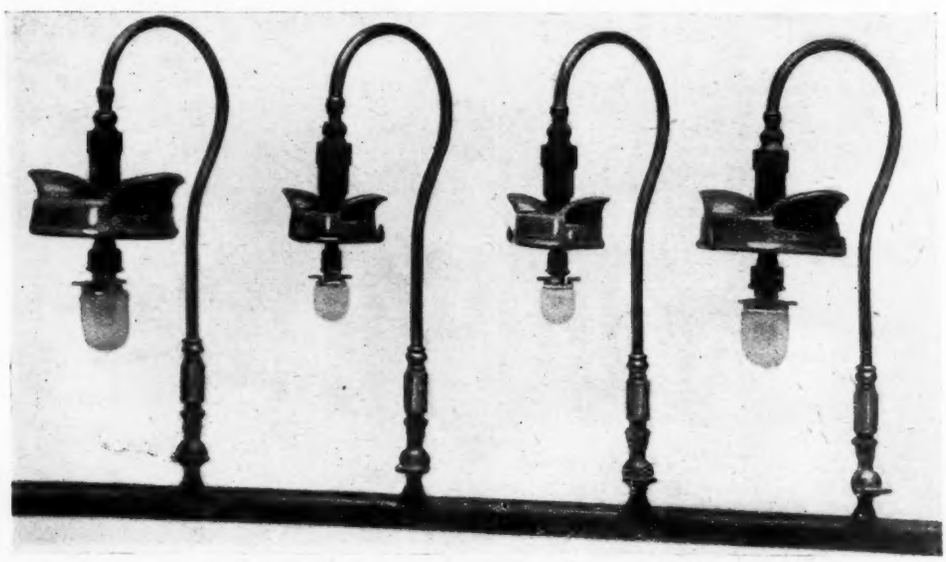
(1) The experimental determination and specification of all kinds of burners suitable for working under the extreme conditions met with in their subsequent use;
(2) The assembling of component parts for the bulk manufacture of standardized burners;
(3) The verification from time to time of the duty rendered by burners supplied in bulk; and
(4) Further experimental work tending to enhance the efficiency of the appliances.

[In the Appendix to the paper a series of photographs was shown of the Physical Laboratory and the Gas Burner Production Department at Old Kent Road. Also photographs of some of the operations in connection with "Metro" burner production.]

From the first inception of the system developments followed in orderly sequence as a result of detailed attention to the outdoor requirements. Standard glassware, gas mantles, and gas fittings, etc., of every description are carefully considered in the matter of design and mechanical structure, as well as their physical properties and specifications are drafted to which manufacturers are asked to conform. A system of limit gauging is in operation by which interchangeability is secured, and sizes are checked.

The success that has attended these efforts is largely the result of collaboration on the part of all the Departments concerned. That there have been many difficulties will not be wondered at, but it is a matter for satisfaction that the success which has been attained amply justifies the policy pursued.

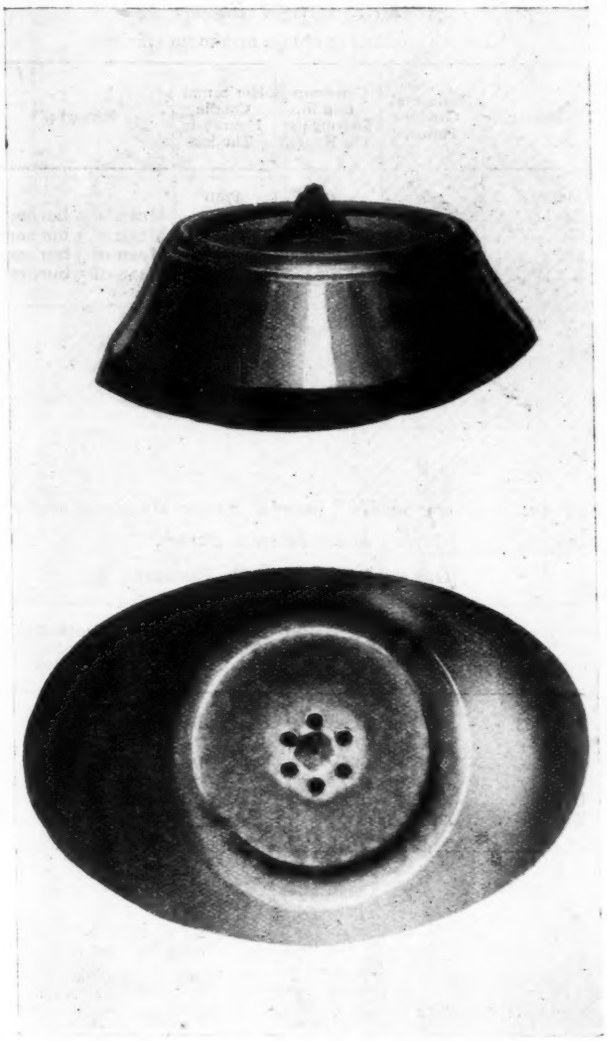
While discussing the question of incandescent burners reference must be made to the problem of dust, which is a matter of importance. A dust-laden atmosphere is one of the evils inseparable from the life of a town dweller. One has only to observe the myriad particles which are made visible by a beam of light to discover at least one cause of some of those ills and diseases to which flesh is heir. These solid matters which pervade the atmosphere in course of time tend to impair the working of the burner. Some



FOUR "METRO" INVERTED BURNERS IN USE SINCE 1912.

of the dust particles which are taken in along with the air through the primary air ports are deposited on the ejector in the immediate vicinity of the gas orifices, and as a result the issuing jet of gas is to some extent interfered with. It is therefore desirable that provision be made for the easy removal of the dirt which accumulates. A microphotograph is shown of a "Metro" gas burner ejector on which the deposited dust is clearly seen. This was one of the chief points studied when designing the burner. The bayonet method of attaching both burner and glassware has proved a boon to consumers, who appreciate the ease with which all parts of the burner can be cleaned.

The question of dirt and dust in the air raises a point which is of considerable importance. It is not always realized that by the use of a gas flame myriads of microbes harmful to health and which are present in the air are cremated, and the air of a room is in that measure sterilized.

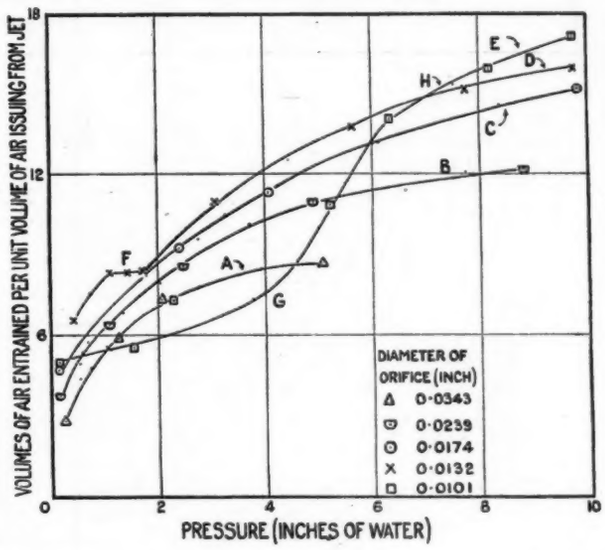


Microphotograph of "Metro" Gas Ejector Showing Accumulation of Dust.

Not only therefore is an incandescent mantle a miniature sun giving forth soft rays of light, but the flame is a destroyer of germs, and to that extent becomes a guardian of health. The blackening of walls and ceilings by hot-water pipes and radiators should be, if properly used, one of the strongest arguments in favour of gas lighting.

Comparatively little information is available of the conditions determining the entrainment of air by gas issuing from the bunsen burner jet. Among other factors its pressure and density are intrinsic qualities of the gas which condition the amount of air entrained, while the *form* of the issuing jet exercises considerable influence not only upon the degree of air entrainment effected, but also upon the actual discharge from the orifice.

The effect of the form of the issuing jet, and more especially of the greater or less area of surface of the jet, upon air entrainment is very clearly shown in some recent experiments carried out by Dr. J. S. G. Thomas in the Physical Laboratory at Old Kent Road. Curves are shown below which illustrate the effect produced upon air entrainment as the diameter of the orifice through which the jet issues is reduced, the thickness of disc being throughout equal to 0·0090 inch. In all cases the orifices were very accurately circular, and the walls were made as smooth as possible. The respective diameters of the orifices were: A 0·0343 in., B 0·0239 in., C 0·0174 in., D 0·0132 in., and E 0·0101 in.; and the curves show the relation between the air entrainment per unit volume of air issuing from the orifice for various pressures in the case of each of the orifices. Considering first the curves A, B, and C, it is seen that for all pressures a diminution in the size of the orifices is accompanied by a greater air entrainment per unit volume of air in the jet. A similar result holds when coal-gas issues from the orifices in question, and the results indicate that a greater degree of primary aeration of the issuing gas can be effected by diminishing the size of the orifice. It is to be anticipated, therefore, that a greater degree of primary aeration is to be effected by the use of a multiple-hole ejector than by the use of a larger single-hole ejector. With certain provisos the conclusion is correct, but in attempting to effect a greater degree of primary aeration by reducing the size of the orifice, regard must be paid to two outstanding factors. In the first place, the orifices in the multiple-hole jet must be disposed so that the air entraining powers of the several jets are not reduced



by mutual interference of the jets. Such interference reduces considerably the degree of primary aeration effected, and tends to render the jets unstable, producing in the case of a gas-burner an unstable and flickering flame.

It is clear from the figure that there is a limit of size below which the orifice cannot be advantageously reduced from the point of view of efficient air entrainment. This is first evidenced in the curve D, for, as shown at F, there is clear evidence of the existence of a disturbing factor whereby, for a range of pressures ranging from one to about three inches of water, the degree of aeration effected is somewhat reduced from its anticipated value. A detailed investigation of this point has shown that the reduction originates owing to turbulence impressed upon the stream entering the orifice, and persisting until the stream issues in the form of a jet. The effect produced by still further reducing the size of the orifice is clearly seen in curve E. In this case, for values of the pressure up to about 5 inches of water the degree of aeration of the jet effected is actually smaller than that effected at the same pressure in the case of the jet issuing from any of the larger orifices. Furthermore, a gas burner operating under the conditions represented in the curve E, by points between G and H, would of necessity afford a very unsteady and jumpy flame, for any slight variation of pressure under these conditions would produce a large alteration in the degree of primary aeration effected.

Some reference must now be made to that most vital part of our illuminating devices, the mantle itself. For

many years the South Metropolitan Company kept a reserve store of rare earth salts sufficient for the production of mantles in large quantities. But this did not afford the expected security during the period when pre-war stocks of mantles had been depleted, and it was not comfortable to feel dependent upon manufacturers who suddenly, for undefined and unexplained reasons, were unable to supply even a reasonably efficient mantle. How much our business suffered from the defect is an unknown quantity, but it must have been very considerable. The fact was not pleasant to contemplate that we were unable to help ourselves in the matter, for, despite investigation extending over a good many years into the merits of various types of mantles, weaves, and impregnations, our work was mainly academic in character. But the gas industry itself should lay down the conditions necessary to make experimentally the article it requires to buy commercially—that is, a high-class high-efficiency mantle, free from some of those defects which to-day seem inseparable from a large proportion of the marketed qualities.

So much for the gas burners; what of the moral?

On the foundation-stone of our outdoor business was, years ago, carved "take care of the lights, the stoves will take care of themselves." But those words would provide only an incomplete answer to the question. An experience of many years has led the author to think that too often unsuitable methods are followed in providing for the needs of those branches of works design and management, chemical and physical investigation and control, gas salesmanship and gas technology, into which our industry most certainly divides to-day. If by "gas engineer" was meant a person qualified to design and manage gas-works when

Results of Four "Shoddy" Upright Burners compared with a Metro Upright Burner.

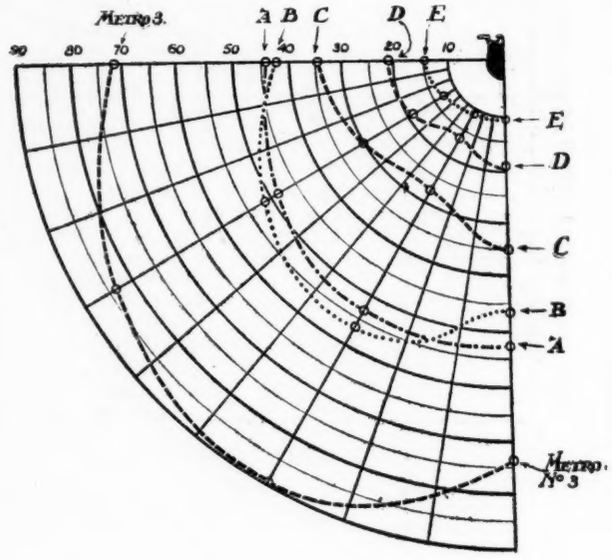
[Gas tap full on—40-10ths in. Pressure.]

Burner.	Horizontal Candle Power.	Consumption in Therms per 100 Hours.	Horizontal Candle Hours per Therm.	Remarks.
Metro .	98	2·96	3310	—
B . . .	36	3·66	980	Mean of 6 burners.
C . . .	60	3·45	1740	Mean of 3 burners.
D . . .	24	3·79	630	Mean of 3 burners.
E . . .	12	4·42	270	Mean of 3 burners.

Results of Four "Shoddy" Upright Burners compared with a Metro Upright Burner.

[Gas tap checked to obtain maximum efficiency.]

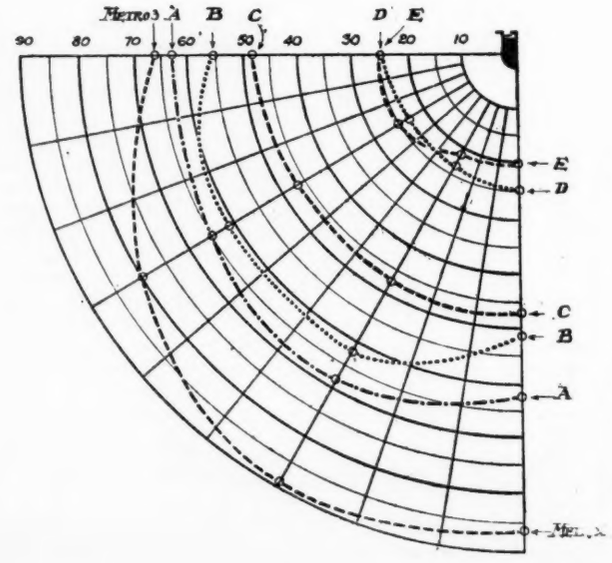
Burner.	Horizontal Candle Power.	Consumption in Therms per 100 Hours.	Horizontal Candle Hours per Therm.	Remarks.
Metro .	96	2·58	3720	—
B . . .	58·3	2·37	2460	Mean of 6 burners
C . . .	61·9	3·06	2020	Mean of 3 burners
D . . .	35·2	2·28	1540	Mean of 3 burners
E . . .	14·4	1·64	880	Mean of 3 burners



Results of Five "Shoddy" Inverted Burners Compared with a No. 3 Metro Inverted Burner.

[Gas tap full on—40-10ths Pressure.]

Burner.	Mean Radial Candle Power.	Consumption in Therms per 100 Hours.	Mean Radial Candle Hours per Therm.
Metro 3 . . .	84	2·75	3060
A	49·5	3·07	1610
B	49·5	3·39	1460
C	31·7	3·58	890
D	19·2	4·05	470
E	12·5	4·53	276



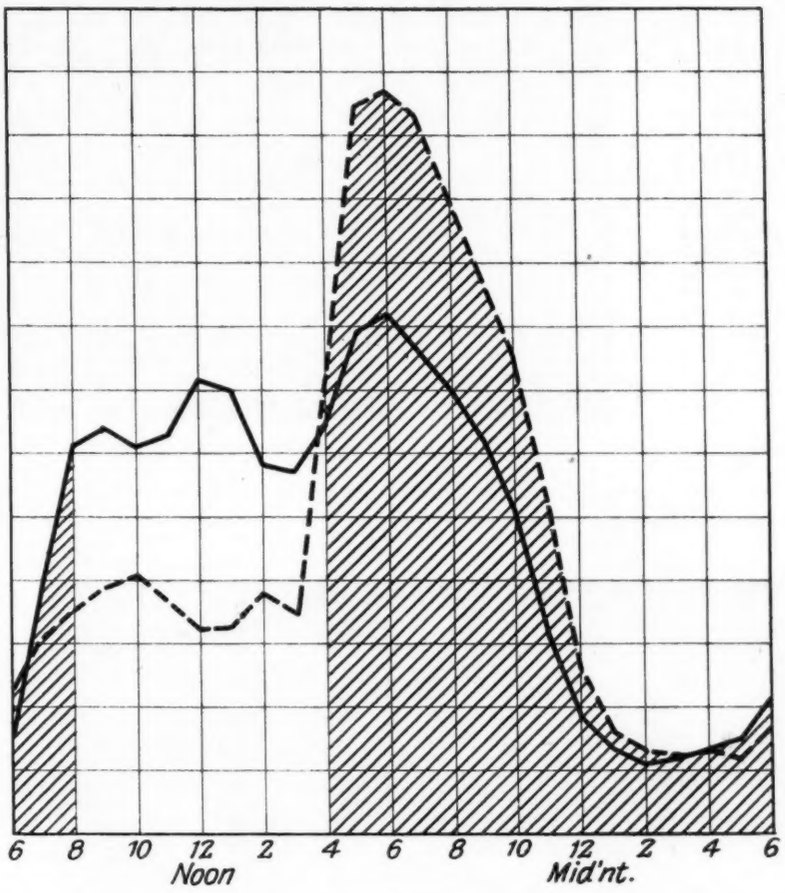
Results of Five "Shoddy" Inverted Burners Compared with a No. 3 Metro Inverted Burner.

[Gas tap checked to obtain maximum efficiency.]

Burner.	Mean Radial Candle Power.	Consumption in Therms per 100 Hours.	Mean Radial Candle Hours per Therm.
Metro 3 . . .	81	2·06	3930
A	65	2·21	2940
B	58	1·80	3220
C	48	2·03	2360
D	24	1·78	1350
E	23	2·51	920

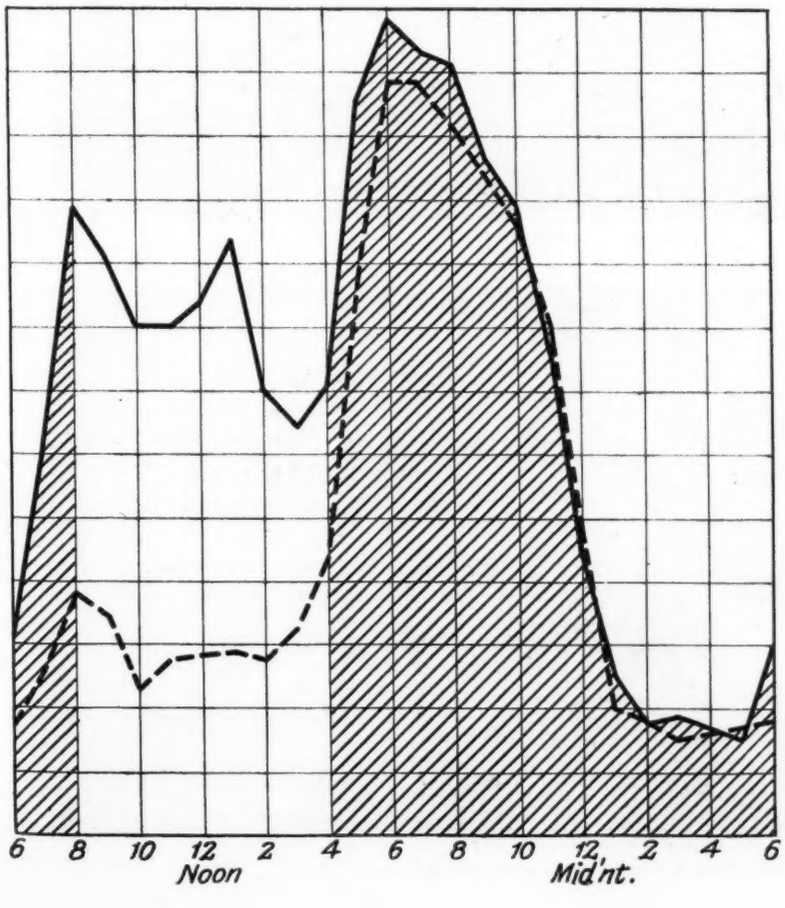
COMPARISON BETWEEN TWO TYPICAL WINTER DAYS' OUTPUT OF TWO GAS UNDERTAKINGS.

[The Shaded Portions show the Lighting Hours, and the Curves the Outputs in the Years Noted.]



Case A.

——— 1919
&
--------- 1889

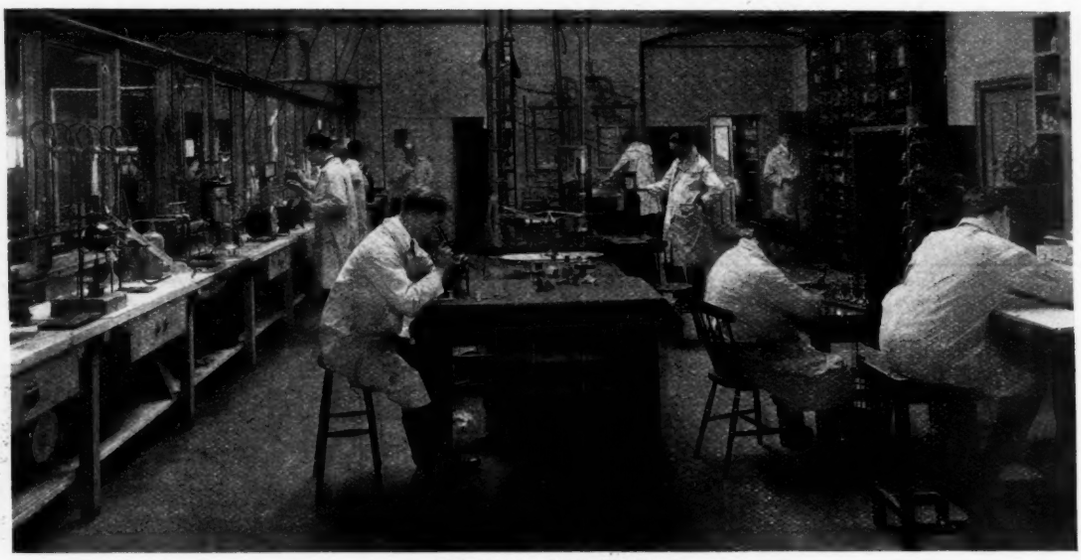


Case B.

——— 1919
&
---------- 1890

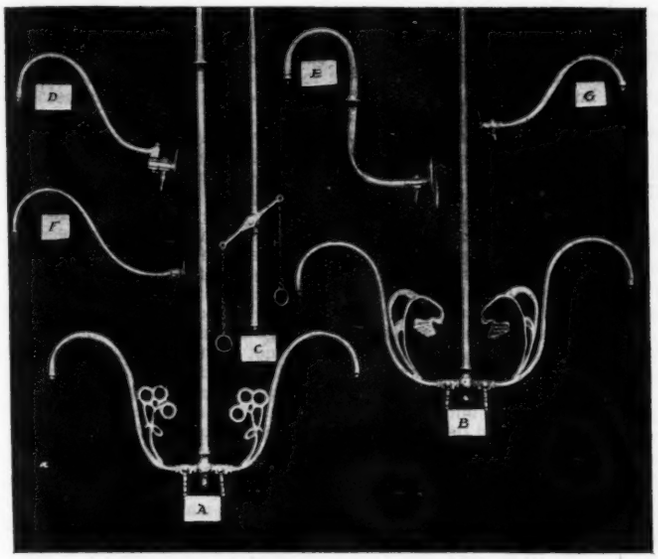
Test of Various Cheap Pendants and Brackets. Shown in Photograph.

Ref.	Description of Fitting.	Price.	Point of Leakage.	Leakage in Therms per 100 hours at 30/10 pressure.	Results of Gauging.		Remarks.
					Nosepieces.	Top and Back Connections.	
A	2-Lt. Pendant	s. d. 13 6	Base of Stem	0·48	Not to Gauge	Not to Gauge	
B	2-Lt. Pendant	15 6	Arm Joints	0·55	,,	,,	Defective Nighting
C	1-Lt. Pendant	4 0	Cup and Ball	0·05	,,	,,	
D	1-Lt. Bracket Single Swing	3 0	Plug	0·06	,,	,,	Plug Fixed in Inverted Position
E	1-Lt. Bracket Inverted	3 0	...	...	,,	,,	Plug Fixed in Inverted Position
F	1-Lt. Bracket Inverted	3 6	...	0·050	,,	,,	Defective Plug
G	1-Lt. Bracket Inverted	5 3	...	...	,,	,,	Plug Fixed in Inverted Position and Defective Tubing



PHYSICAL LABORATORY.

BURNER PRODUCTION DEPARTMENT.
Standardization of Ejectors and Examination of Flames.



"Shoddy" Fittings Purchased from Local Vendors.

a former occupant of the Presidential chair uttered the dictum that "it is not only the duty of the gas engineer to put the gas into the holder, but it is his duty to sell it," then I differ fundamentally from his dictum. A combination of more qualities would be required than would be forthcoming except in the Admirable Crichton of the dramatist. And in this subdivision of, or specializing in, the work of carrying on and extending this great industry, I earnestly appeal for a wider appreciation of the science of burner design. Where would the electric lighting undertakings be to-day without their standard lamps? How can gas lighting progress unless full advantage is similarly taken of its enormous possibilities? Surely the question transcends all others in its importance to the gas engineer. This Institution will not be worthy of its origin or of its aims if it ignores so pressing a necessity. It rests with the gas engineering profession to make gas not only the light of the present but of the future if it will but take a due share of the tasks involved in perfecting its uses and spreading the knowledge of them far and wide.

In the diagrams on p. 859 are curves representing the load lines of two adjoining companies supplying gas to one of our largest cities. The horizontal scales are the same; the vertical ones in the case of the larger undertaking have been corrected for comparison purposes to the smaller one.

The diagram is submitted as justification for the belief that there is a moral associated with this paper.

The author has to acknowledge the great obligations he is under to the staff of the South Metropolitan Gas Company, whose work has formed the basis of this paper, and among whom he desires especially to mention Messrs. Albert Stokes, John Somerville, Dean Chandler, and Dr. J. S. G. Thomas.

The PRESIDENT: We have listened with very great interest indeed to this paper on a very important subject. I have not looked back on our Transactions during the last few years, but I think it is a very long time since we had a paper dealing with lighting. As I mentioned yesterday, the question of lighting must not be lost sight of. It was for this that the industry first came into existence; and there is no reason why we should not maintain our lighting load, provided we have the proper apparatus, and it is properly maintained. ("Hear, hear.") I agree perfectly with what Dr. Carpenter has said with regard to shoddy apparatus, not only in regard to lighting, but in some other respects, which many of our consumers have adopted. It is a great pity, and it has done us a great deal of harm. Whether the suggestion which Dr. Carpenter makes is one that we can adopt is a matter that requires very careful consideration. At the moment I am not prepared to express an opinion on it; but I certainly think that the Institution should, and can, take steps to ensure that apparatus, at any rate that which is recommended by gas undertakings, is safe in use. In regard to any other means whereby we can make our apparatus safer, we should in every case make certain that that is brought prominently to the public notice. With regard to the apparatus itself, the supplies throughout the country vary to such a great extent that that can only be decided after careful consideration. The paper is open for discussion.

Discussion.

Mr. GEORGE HELPS (Nuneaton): I have no doubt that an immense amount of good will be done for the industry by a good discussion on this paper. Near the end of his paper, Dr. Carpenter says: "I earnestly appeal for a wider appreciation of the science of burner design." Once I spent the best part of my time in trying to bring about improvements in burners. For the last two or three years I have given it up entirely, because I think, from my point of view—of course, you all disagree with me [Laughter]—that lighting is the least important direction in which we should apply our energies. We can give the consumer very few advantages, if any, over electric light; whereas if we look to burners designed from the point of view of industrial and domestic heating, there is another outlet. As a concrete fact, I may state that I know of a house where they cook for nine people for a whole year with gas obtainable from 1½ tons of coal. If you compare that consumption—300 therms per annum—with what the average consumer uses for lighting, you will find that something like 100 lighting consumers will become equal to one cooking consumer. A very important fact indeed in connection with the matter is this, that it has been stated at these meetings that the usual process of gas manufacture is such as gives an efficiency, when stated in all sorts of ways—therm efficiency I think the scientific people put it—of 80 p.ct. When you look at the figures, you find that what we get from a ton of coal is 20 to 25 p.ct.; we are making about 60 p.ct., or something like that, of coke. This is very important. Dr. Carpenter, of the South Metropolitan Company, has shown us how to make gas in his own particular way. That excellent paper we had last year, given us by the Chief Engineer of the Company, is well within our memory. To get 300 therms, he used 4·37 tons of coal. It is true he has got coke; but that has nothing to do with it. The yield is the main factor affecting the price at which we are compelled to sell gas; and those 300 therms should be made from 1½ tons, or something like it. If you will just consider what these figures mean, you will have some idea of what I have been driving at for the last ten years. I thank you for giving me this opportunity of speaking.

Mr. THOMAS GOULDEN (London): I should be sorry for it to go forth from this meeting that any member of the Institution of Gas Engineers in anyway deprecated the lighting load. ("Hear, hear.") I do not consider by any means that we should neglect the lighting business. On the contrary, the heating business can take care of itself, to a very large extent, because it is obviously necessary, although I would not suggest neglecting it; but the lighting business we should foster by every possible means. I do not think anything can show this more clearly than these very instructive diagrams. Take case B, for instance. The lighting load in 1919, as compared with 1890, actually increased, showing that the lighting load can very well be kept up, although in the case of another concern the lighting load had considerably dropped. I think that in itself is sufficient of a moral to cause us to feel a deep debt of gratitude towards Dr. Carpenter for his paper. The object of us all is to supply cheap gas; but I was sorry to see, in the papers this morning, some publicity given to the fact that apparently one gentleman of our body of engineers wishes to sell cheap gas, and that the universal wish of the others is not to do so! I should suggest a careful comparison of prices in the different districts which we supply, in order to find out where the truth lies. ("Hear, hear," and applause.) I congratulate Dr. Carpenter very much on the paper he has given us, and I congratulate the Institution upon having received it. We are at one with regard to the matter of supplying good fittings and burners; but I must point out that there always seems to me one difficulty—we can only arrive at the end we desire by the gradual education of the public. We cannot force it upon them, because there must be always a very large section of the public that will buy from the ironmonger and the outside shop so long as they can buy things more cheaply. That is always the difficulty in the way of getting really good fittings throughout our districts. I think we can best arrive at the end we have in view by way of education, and I cannot conceive a better education than by means of papers such as Dr. Carpenter's being given the very widest publicity possible. Of course, we have our opinions in regard to this matter of standard fittings and unvarying supplies of gas and air in relation to one another; but, as he has rightly pointed out, in order that they should work at their best under these conditions, we must have a standard gas. We have our vertical retorts, and total gasification coming along, and it is clear that some considerable time must elapse before we can get a standard gas. If we can, I fully agree that we shall get the best results under conditions that Dr. Carpenter has so ably demonstrated. It is a little reflection, possibly, on gas engineers, that the invention of these new burners has not been by them; and this again points the moral that we should have our own specialists to deal with these matters. There is that peculiarly beautiful lamp of Mr. Wenham's. I think he was an optician, and he had something to do with the handling of very delicate lenses, and so on. It is the same with the Welsbach mantle; but, with regard to the adaptation of the Welsbach mantle to the gas industry, in the first place

we must recollect that not only were the early mantles very fragile, but also when the mantle was first introduced the burners were very expensive. Dr. Carpenter himself has borne testimony, and rightly so, to the tremendous advantage to the gas companies in the early days of lighting of our having been able to sell cheaply, or to give the flat flame burners away, to the consumers. It helped us very much indeed at a later date, because the fact that we could afford to give the burners away was a very strong point in the obtaining of the various Acts for the lowering of the illuminating power. I can only repeat my congratulations to Dr. Carpenter, and to the Institution, on this very valuable paper.

Mr. H. E. JONES: With regard to the diagrams shown, in the first place I should like to say that unless you have all the conditions attaching to these two diagrams before you, they will not lead you to very accurate conclusions. We cannot get away from this: that no flat-flame burner is going to compete, in convenience and cost, consuming the quantity of gas it does, with the electric lamp supplied to-day with the metal filament. We badly want a switch. By way of comparison take, for instance, the City of London. You have buildings of six or seven stories—a class of building you do not find in the suburbs—and the need for internal lighting all day long. I was compelled to quit my rooms in Palace Chambers and to go into some dog-holes, where I could not get on, on any but a very bright day, without artificial light. Artificial light from metallic filament lamps apparently costs so little that I was very sorry for the electric light companies. They are suffering from the same difficulty as we were when the Welsbach mantle came out. But you cannot shut your eyes to the fact that if you go into any office, theatre, or restaurant in London proper you find that, although they cook food and make tea with gas, they will have electric light in those rooms above the building which they have to use occasionally. Unless you have all these data, it is misleading to say that in one particular area they have not developed the lighting load as fast as in another area. I am concerned with lighting in the suburbs and outer suburbs of London. There I know that the lighting load goes on very well, because electric lighting does not pay in the scattered areas; but it does in London, where it is pushed. It is convenient and cheap, and it is hopeless for us to attempt to exclude it. A friend of mine said to me years ago: "Why don't you go into the kitchen, and let me go into the drawing-room, with electric light." They are now in the drawing-room, and I am afraid we shall not shut them out. We hear of injury to the eyes through electric light. I have to read in London by electric light, because I cannot get any other; but in my country home I have a burner which Dr. Carpenter gave me 14 years ago, which is perfect, and there is no comparison. It is a "Metro" burner, and it is a very well-made burner indeed. It is a beautiful invention, collects no dust, and requires no cleaning. I have inferior inverted-mantle burners in the house, and they are very troublesome. This burner has only had two mantles in 14 years. [Laughter.] I wonder why you laugh. Such is the beauty of the burner that it protects me against the servants having constantly to take them off, tickling the burner up and blowing the dust out, and all the other things that happen with the common burner. It is up to me to acknowledge the handsome gift of that burner, and I read as long as I can with the light from it. I have a friend, an old doctor, who told me that it makes him unhappy to read with electric light in the club. Gas has not that actinic ray which, penetrating the eyelid, damages the sight; every doctor knows this perfectly well. But you will never drive electric light out of the dark passages and little dark, badly-lighted rooms in the City and West End of London, where you cannot possibly hope to develop the flat-flame burner—first, because the burner is not so convenient, and secondly, it is more expensive; and why anyone should advocate that we should use a burner which consumes five or six times the amount of gas, I cannot conceive. I have no sympathy and no compassion for the man who wants to use a flat-flame burner to-day.

Mr. J. FERGUSON BELL (Derby): I should like to say how much I feel that we of the gas industry are indebted to Dr. Carpenter and to the South Metropolitan Gas Company for all they have done for the industry in the way of lighting. Our lighting load is an important one, and we should take care that we do not easily give it up. My particular object in rising is to say that most gas companies and most municipalities now have showrooms, and in them they can show the best and most up-to-date fittings. I venture to hope that the result of this paper will be that in any of the showrooms which we enter we shall never see inefficient burners and inefficient fittings, but English goods of the best quality. If we are going to expect manufacturers to supply us with a good article, we must expect to pay a reasonable price. I told the superintendent of the showrooms that I control that we were going to have "Metro" burners. I am using a "Metro" burner, and have used it in my library for some years. I was not quite so fortunate as Mr. Jones, who had one for a present; I bought it. (Laughter.) It has proved a good investment, and any consumer who buys a "Metro" burner will find it a good investment. I appeal to all those who control showrooms to say that they will have only the best in those showrooms. Dr. Carpenter has pointed out that we, as a gas industry, are often held to blame for accidents arising from gas. These accidents arise, not from gas, but from the use of defective fittings; and it is our duty to educate the consumer. When a consumer comes into a showroom, and we show him the best fittings, in a large number of instances he can be converted, and he is willing to pay a slightly higher price for the best article. The heating business, also, is a very important one. It is not a business to take care of itself; it wants looking after. As Mr. Jones has pointed out, the great competitor in our lighting business is electric light; and this is, of course, owing to the convenience of switching on and off. In Derby the Corporation, with the assistance of the Government, have fitted-up a large number of artizan dwellings with electric lighting. We fitted them with cooking apparatus, gas-fires, boiling burners, &c. But what do the people say? They say they want the gas, because, having got the gas service, it costs so little to use it also for lighting. This is the position all over the country; and I venture to say that if we see that the best appliances are brought to the notice of the consumers, we shall retain a very large amount of the business. There is no reason why we should not try to maintain what we have got, because our lighting load is important. I sometimes hear gas engineers say that we are losing our lighting load. But let us bear in mind that our industry was founded on the lighting business; and there is no reason why we should lose that business. I should like to say with what pleasure I have listened to the paper, and congratulate the Institution on having a contribution brought before it pointing out the importance of the lighting business, and also bringing before the members what can be done by up-to-date improved lighting.

Mr. H. E. COPP (Hull): I have been perfectly amazed at the small amount of progress made in the construction of burners, with the exception, of course, of that made by Dr. Carpenter. I much question whether the burners obtainable to-day are any better than those of ten years ago. I am referring particularly to the type of burner fitted with adjustment. Of course, the fixed nipple burner is admirable where you have standard gas; but it is absolutely impossible in the case of nine out of ten of the undertakings represented by those in this room, simply because we are so unfortunately placed that we have to take up half our load with water gas at times. We have not all such good coke markets that we can keep our yards free from coke, and we have to utilize it in the direction which Mr. Helps has been pointing out. As to varying length of flame, it is obviously impossible to fix a limit. If you have all coal gas, or all water gas, all well and good. I am very much indebted to Dr. Carpenter for having pointed out the shoddy nature of some of the burners obtainable. This has done the gas industry more harm than anything I can think of. One sees so many obviously badly-made burners. Many of them give you a good flame when you put them on, but they soon deteriorate. I think it is a point which Dr. Carpenter has done very well to emphasize.

Mr. F. W. GOODENOUGH (London): I should like to add my appreciation of the paper. There are just two things I should like to say. One is that I am strongly of opinion that there is no side of our business which should be left to take care of itself. (Hear, hear.) The gas-fire business was in a lamentable condition some years ago owing to bad construction, worse fitting, and equally bad appearance of some gas-fires. I think the gas-fire business needs as much attention as the lighting business; and I am sure there is no side of our business that should not have the fullest care and attention. Everything possible should be done to develop the use of gas throughout our districts. The other point I want to make is in regard to the two diagrams. Of course, we do not know in the least to what districts they refer, but supposing, as a hypothesis, that case A refers to the Gas Light and Coke Company (laughter), I want to point out two things. First, the high day-lighting load of earlier years referred to a time when the Royal palaces, all the leading hotels, theatres, restaurants, West End mansions, West End clubs, &c., used gas lighting. They had the Metropolitan district, which is unique as being the richest area in the world, including also the City of London, with its banks, insurance companies, sky-scraper offices, &c. The manager of a bank said to me once, when we were discussing the relative cost of gas and electricity for lighting, that the more I demonstrated to him that gas was cheaper than electricity, the more determined would he and the companies be to use electric light, in order to give an appearance of prosperity. That applies to many of the large houses, where the desire of those who occupy them is to show that they can afford the most expensive things money can buy (laughter). It is interesting to know that, taking the curves of to-day, the lighting load in one district is in about the same relative proportion to the day load as in the other; in other words, formerly the lighting load was much higher in one district than in another in comparison with the day load, and now the relation is practically the same.

Mr. C. F. BOTLEY (Hastings): If this paper results in stimulating interest in regard to gas lighting, I feel the industry is to be congratulated, and Dr. Carpenter will, I am sure, feel that he has been rewarded. I have felt very strongly lately that there has been great neglect of the lighting load in the gas industry. It has seemed to me (rightly or wrongly) that a great many of our friends, some of the members here perhaps, have looked upon it as being inevitable that electricity must take the place of gas for lighting. This is a most unfortunate aspect of the matter to get into one's

mind, because to-day I think I can say, certainly from my own experience, that gas as an illuminant, with the facilities that are offered in the beautiful fittings, even the switch system—which is possibly not as perfect as we should like—is in a better position than it ever was to compete with electricity. It is a great pity indeed that electricity has been allowed to forge so much ahead, although, of course, none of us disguise the fact of the inherent advantages which electricity has. But, taking the ordinary household which has got a gas supply, it always seems to me the utmost folly and waste of money to instal electric lighting when they can, with the same service, at a very small cost indeed, have gas lighting installed as well as cooking. There are those of you, I am sure, who have had a consumer who has put in electricity and expected a great reduction in his gas bill, but has not found that reduction. It is simply due to the fact that the cost of gas for lighting to-day is infinitesimal. Added to the ordinary load, as Mr. Bell has indicated, it is practically nothing, and it seems to me the greatest possible folly, when gas is laid on, that it should not be used for one and all purposes, which it can be with the greatest possible success. Having said that, there is no getting away from the fact that in competition with electricity we are faced with a great many difficulties. Possibly one calls to mind one's own experiences in these matters, which give a moral.

Following up this question of the neglected lighting load, I have held, during the last autumn, a good many meetings of my staff, and the conclusions which we came to in regard to the loss of lighting load in our particular town (you will remember that we are in competition with municipal electricity, which has a very important bearing on the matter, because, in the ordinary way, economic considerations do not concern a municipal undertaking) were, first, that the competition of these abominably shoddy burners is a very serious one indeed, and it is a very difficult thing to stop; and, secondly, that we wanted something to compete with these particular burners—a good burner at a very low cost. In this direction we have been trying to move. Unfortunately, I do not agree with Dr. Carpenter as to the fixed nipple and fixed air regulator; but that is a different matter. We have for years (I think ever since 1892) not been in a position to enforce our wishes upon the consumers, but merely to guide them—we have always endeavoured to set the best possible example in regard to gas fittings and appliances. I never allow anything in the showrooms but what can be thoroughly recommended. We have some of the original Welsbach burners in our town to-day, which are doing splendid service. It is easier, of course, in a small provincial town, because what can be done there is not so easily applied to the huge areas some of you deal with. But we have set a good example, and, to a large extent, eliminated these bad gas-fittings, except for the people who go into a shop and buy one of these stupid burners and mantles. We cannot, of course, compete with that.

Coming to the question of the use of electricity, of course, we find it in our so-called artizans' dwellings—no artizans live in them, but they are called artizans' dwellings—and they have perforce to use electricity. There is nothing we can do to stop it; but they would much prefer to use gas. But it is the fashion to-day to use electricity. Mr. Goodenough mentioned the banks; and perhaps they would use marble when the rest of us would have to use concrete. They do it in order to show how much money they have to throw away. At all events, that is one aspect of it. One of the great difficulties, apart from these inferior burners, to my mind, is the fact that it is the fashion to have electric light. One of my Directors is a shopkeeper, and he decided to have his gas lighting modernized. Some of his friends thought he was a lunatic; but he is not. He has got increased illumination at decreased cost; and he does not forget to tell those particular people. But it is in the people's mind to-day that if you are going to do anything to lighting, don't spend a few shillings modernizing gas, but spend a good many pounds and have electricity. Carrying that further, in our town we have at the present time electricity installed in many cottages. Of course, a good many of these cottages are occupied by municipal employees, who may, or may not, get an advantage in the charge for current; but I noticed the other day, in passing such a cottage, that electricity was being installed. The house had not been painted externally for several years, and there were no blinds to the windows. They would have electricity, but they could not put their place in proper repair. I instance that to show you how much it is a question of fad or fashion. Evidently, by reason of that electricity, they might be able to sell the house at a great advantage, and that aspect to-day is a serious one. I hope that, as a result of Dr. Carpenter having brought this before us, we shall pay more attention to lighting in future, and not let it go simply because it is a little trouble to continue.

Mr. W. J. LIBERTY (London): I rise to offer my meed of thanks to Dr. Carpenter for his excellent paper. It comes as a refreshing breeze to have a talk on this part of the industry. It is a long time since we spoke about it. I think it was in 1911, in Glasgow; and it is one of the problems that are worth considering. If nothing other than the elimination of the shoddy stuff which is put on the market is the outcome of the paper, then Dr. Carpenter can go away feeling that he has done the Institution a great service. With regard to Mr. Jones' remarks about the central areas of the Metropolis, we know (as Mr. Goodenough has stated) that the bank managers and hotel people will have electric light in their dark places during the day. But, unfortunately, we have here a large number of gentlemen who represent towns and cities from John o' Groats to Land's End, who have not areas of that kind to deal with, and, therefore, these remarks might only apply to the area in which we are meeting this morning. If, as a practical outcome of the paper, the Institution can see their way clear to appoint a small committee to go into the question of the standardization of burners and fittings, I think it would be a good thing. Everything now is being standardized. We all know how difficult it is, when an article wants repairing, to get spare parts. It would be a help to have a standard specification which we could submit to architects and builders. If such a specification were in being, it would do more to kill the shoddy burner than all the talk and the paper (excellent as it is) that we have had this morning. I commend such a thought to you, Mr. President and gentlemen, that at your Council meetings you might take it into consideration. It would be a great tribute to pay Dr. Carpenter for having come among us this morning.

Dr. CARPENTER: I cannot but be gratified at the reception you have given my paper. My regret is that circumstances interposed, and prevented my making it as full and complete as I originally intended. With regard to Mr. Jones, I am only sorry that at the time I placed at his disposal the burner to which he has referred I did not give him my switch. With regard to the use of electricity and gas, I think it is an exceedingly good thing for gas, as I think also for electricity, that the two supplies are in competition with each other. One of my pleasures is to have placed before me (which I do regularly) a list of people who, within the last week or so, have had electric lighting taken out of their houses, &c., and incandescent gas installed. (Laughter.) That may be surprising Mr. Jones; but I can assure him that it is one of my routine tasks and pleasures to look through that list. I am afraid a little misapprehension has arisen with regard to the fixed air and gas nipple. If I may exclude a certain portion of the war period, when things were exceedingly difficult all over the country, then I may say that in the last fourteen years (all our gas-burners and all our gas-fires in Westminster, where I live, are fixed air and fixed gas) we have had no trouble. This shows that fixed air and fixed gas will stand up to whatever variation has been required in carrying on the work of the supply of the largest Gas Company in the kingdom. It is, of course, important to do all we can to keep our business up to standard pitch, be it gas lighting, heating, or anything else. If anything I have said to-day will help that result, I shall be well repaid for the small trouble I have taken in the matter. I should like to repeat the acknowledgment I made in the paper of the debt I am under to those members of the Staff who have so carefully and thoroughly carried out the work of investigation. They have not only carried out the work of investigation, but brought about the results of the large and extended use of these appliances in South London. In conclusion, I should like to say this, by way of apology, as to why I am here at all. It has been my pleasure to be on terms of friendship with the Chief Technical Officer of the Gas Light and Coke Company for many years. In the nature of things, I am getting on in years; there are new generations coming along; and friendship does not mean the same thing as it used to to me. I feel, however, that if in any way I can help the President, I am sure I will, and I am sure he would help me if he could in any way. When he wrote and asked me to prepare a paper for the meeting, I thought there was only one thing to do, and that was to consider what was the best subject I could take. I am gratified to-day to think it has met with your approval.

INCREASING THE RATE OF CARBONIZATION.

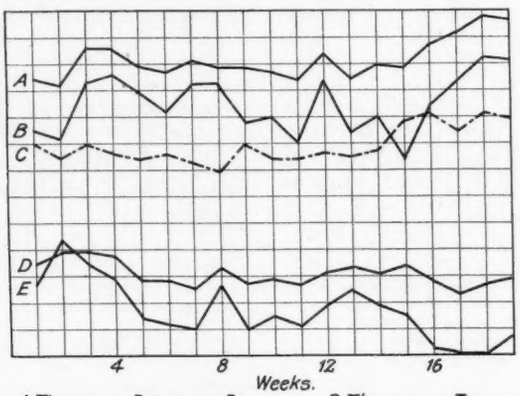
By GEOFFREY WEYMAN, D.Sc.

The rate at which coal is carbonized is obviously fundamental to the economics of gas production. Labour charges are reduced, maintenance charges are diminished, and capital cost is lessened almost in proportion to an increase in rate. But there are other less obvious, but none the less important, advantages in a rapid rate of carbonization.

In addition to the rate of carbonization, two other important factors have to be kept in mind—the thermal yield in gaseous form per ton of coal carbonized, and the calorific value of the gas. Owing to the operation of the Gas Regulation Act, the latter factor is fixed by the "declared" value; and gas has to be manufactured as closely as possible to this value. But it is to be admitted that the calorific value should be fixed in the first place only with due regard to plant and conditions of manufacture, and especially of the type of coal carbonized. It does not by any means follow that thermal yields per retort and per ton are inversely proportional to the calorific value.

Large Scale Observation.

From observation of the working of a continuous vertical retort plant—a type of plant in which variations of rate and quality are easily seen—it has been found that increase in thermal and volume output per retort is usually accompanied by increases on the tonnage basis. The curves (fig. 1) taken from the works records, which the writer is permitted to show by the courtesy of Mr. Frank P. Tarratt and the Newcastle and Gateshead Gas Company, illustrate these



A. Therms per Retort per Day. D. Therms per Ton.
B. Cubic Feet per Retort per Day. E. Cubic Feet per Ton.
C. Calorific Value.

Fig. 1.

points. The upper curves show the variations in weekly average output per retort and the calorific value of the gas, while the lower curves show the yields per ton. The variations are large, but not so large as they become when taken day by day, when the maximum reaches 30 p.ct. These variations are chiefly due to variation in the type of coal used. Roughly speaking, and allowing about a week for "lag" in the estimates for coal used, it will be seen that the greater the rate of gas or therm output, the greater the yields per ton. At the fourteenth week the calorific value of the gas was raised by about 12 B.Th.U. by increasing the amount of coal throughput per retort per day. While an increase in the output of gas followed, the reduction in yields per ton are largely masked by variations in the type of coal used.

Observation of the behaviour of different coals in a continuous vertical retort plant; and to a lesser extent in horizontal retort plants, has, in fact, shown that the carbonization of coals approaching coking coals in type invariably gives poor volume and thermal output per retort per day with inferior quality of gas, and usually, but not always, low yields per ton of coal carbonized. It was also found that at such times there was a very marked drop in the temperature of the combustion flues unless precautions had been taken to increase the supply of heat to the settings.

Temperatures taken of the gas leaving the retort were shown to rise up to 100° C. higher than when more easily carbonized coals were being dealt with; but while this is distinct evidence of a larger proportion of gas passing up the retort walls than normally, it cannot fully account for the sudden variation in the temperature of the heating flues. While no proofs can be advanced, it may be pointed out that a small variation in the heat of decomposition of the different coals (say) of 1 or 2 p.ct. of the total calorific value of the coal, would provide an explanation; for this amount of heat would be taken away or added to the heat passing into the retort, which is known to be only a small proportion of that supplied to the setting.

While it is more difficult to observe similar variations in horizontal retort plants, they exist in just the same way; for, after all, the process of carbonization is just as continuous in a horizontal retort as it is in a vertical retort. There is no fundamental difference. In each case the carbonizing zone moves inwards at a perfectly definite rate, decomposing practically completely a fresh portion of coal at each successive period. The rate of carbonization is, in fact, the rate of heat penetration. As the rate of heat penetration through the already carbonized layer is more rapid than the movement inwards of the plastic or decomposing zone, each layer of coal is completely carbonized in sequence. The result is a perfectly even and steady evolution of gas, even from a stationary charge of coal, from the first few minutes to the moment when the heat has penetrated to the centre, when the evolution of gas falls off very rapidly. Other conditions, such as free space above the charge, being constant, the rate of gas evolution provides a good index of the rate of carbonization.

Experimental.

The observations thus illustrated on a large scale have been amplified experimentally. The author has studied many of the factors which influence the rate of heat penetration, by means of a special apparatus designed expressly to emphasize such differences. An account of these experiments has been given before the Society of Chemical Industry.* It was then pointed out that heat is in the first instance transmitted from the retort walls to the charge by conduction, but that this method of heat transmission is very quickly rendered of secondary importance by the setting-up of a non-conducting plastic layer. Transmission of heat is then chiefly carried on by the convection effects of the gases evolved from the retort side of the plastic layer. The composition and properties of the plastic layer naturally vary with the type of coal, and have to be reckoned with in valuing gas coals. With anthracite, the plastic layer can be regarded as absent; with cannel, as being very mobile and easily displaced by the gas pressure; but with the more bituminous type of coals, gas coals, and coking coals, it is present in a more or less resistant form, and plays an extremely important part in determining the rate at which coal can be carbonized. It was found that anything which tended to hinder or delay the formation and continuity of the plastic layer—such as absence of small particles and presence of inert matter—tended also to increase the rate of gas evolution.

These experiments do not, however, provide information as to the effect of these conditions on the quality of gas evolved. Although previous observers have recorded the fact, for example, that coal in the form of "nuts" gives gas of a higher candle power than small coal, the matter may well be studied from a thermal standpoint. It is to be anticipated that the plastic layer must influence the path by which the gas will find its way to the retort outlet; and if the plastic layer is thick and continuous, very little gas will be evolved or find its way through the cool centre of the charge. Most will assuredly have to pass through the coke, where it must be subjected to degradation. The gas must consequently be of inferior quality. Moreover, it also follows in such a case that the output of gas per retort per day is comparatively low, and in large scale practice the gas is liable to be depreciated as well by inert gases, which find their way into the coal-gas stream more easily.

Coal-Testing Plant Experiments.

Apart from practical observation, which is difficult to translate into figures, results bearing on the relationship of the properties of various coals and rate of carbonization have been obtained from experiments carried out in a coal-

* Jl.Soc.Chem.Ind., 1920, 168; 1921, 300T.

testing plant (1-1000th part of a ton scale). The results are of value chiefly because the outstanding difficulty in operating such plants—that of the cast-iron retort—has been overcome by the use of a retort cast in a nickel-chrome-steel alloy. This metal has proved so resistent to the conditions of use that consistent temperatures can be maintained for any required length of time as high as 1100° C. on the inside of the retort. The fall in temperature between the outside and inside is remarkably small, owing to absence of scale; and the temperature conditions inside can be observed with fair accuracy by a pyrometer focussed on the outside.

In the experiments to be described, the coal was in all cases sized by screening and placed in rectangular shallow iron trays with one end open—that facing the retort mouthpiece and ascension pipe. The gas evolved passed through a considerable amount of condensing, scrubbing, and purifying plant before being metered and collected in the test holder. While this meant a comparatively large amount of dead space, it is essential, if the resulting purified gas is to show the normal content of hydrocarbons, that the temperature gradient between the retort and holder should be similar to that of large-scale practice. It was necessary to run three consecutive charges under the same conditions before the results could be accepted.

As a result of a considerable number of coal tests on different coals from the Durham area under the same conditions, it has been found that, roughly speaking, the longer the time a coal takes to reach a certain gas yield (here corresponding to 13,000 c.ft. per ton), the lower is the calorific value. On fig. 2 is shown the average determined calorific value of the

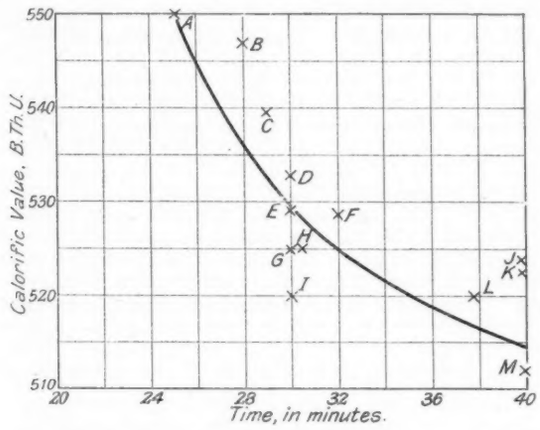


Fig 2.—Calorific value of gas and time taken to obtain the same yield of gas from various Durham coals in coal-testing plant at 1050° C.

gas obtained for a number of coals, and the time taken to reach the standard figure of 13 c.ft. It will be noticed that there is a tendency for the coals to group round the curve. Those which carbonize quickly give a gas of high calorific value, excepting one or two coals H, G, I, which are partially oxidized coals. The coals on the right of the foot of the curve J, K, L, M are such as approach coking coals in type, and possess considerably less volatile matter than the other coals. It would seem that the best thermal yields can only be obtained from those coals which carbonize rapidly.

It has already been shown in a special way that, by paying attention to the physical condition, any coal can be carbonized more readily. A difference in size produced the result shown in fig. 3. In this experiment, selected lumps of the same coal—one of the best all-round Durham gas coals—were broken to pass a 2-mesh and lie upon a 3½-mesh screen. One-half of the sample was then crushed so as to all pass a 60-mesh screen. The proximate analysis of samples of each size was as follows.

Proximate Analysis of Coal used for Experiment, Fig. 3.

—	Size 2/3½.	Size 60.
Moisture	0·78	0·85
Volatile matter	33·93	33·77
Fixed carbon	63·09	63·58
Ash	2·20	1·80

The two grades of coal are very similar. They were carbonized in the usual manner at 1050° C. It will be seen that the larger coal L carbonizes considerably more rapidly than the smaller S, and the difference in rate is maintained

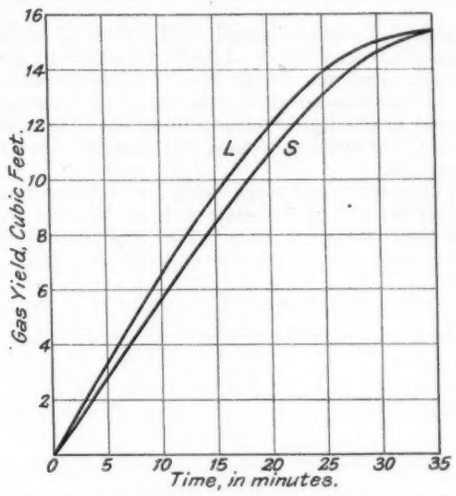


Fig. 3.—Volume of gas yield and time for large (L) and small (S) coal.

up to a yield corresponding to about 14,000 c.ft. per ton. The rate of gas evolution then falls off more rapidly for the larger than for the smaller coal, and the latter catches up at a yield corresponding to 15,400 c.ft. per ton. It was also found that the calorific value was almost exactly proportionately higher for the larger coal L, as the gas output of the latter was greater than of the coal S. Up to a corresponding yield of 14,000 c.ft., the coal L gave a considerably higher calorific value than coal S; but at the final limit of 15,400 c.ft., the calorific value of the gas made in each case was the same—530 B.Th.U. per cubic foot.

In practice, the carbonization would not, of course, be carried to this limit; and if stopped at (say) 14,000 c.ft. per ton it is obvious that both the thermal output and yields per ton would be in favour of the coal L, while the calorific value of the gas would be greater. In fact, nothing but advantage results from suitable adjustment of physical conditions in such a manner. The comparative results of such tests as that described naturally depend on the conditions—such, for example, as the amount of free space above the charge—being kept the same; but in the case given above the free space was unfortunately altered by the fact that the small coal gave a more expanded coke. The apparent specific gravity of the coke from the large coal was about 1·01, and from the small coal only 0·80. Thus the small coal probably had some advantage in the fact that the free space above the charge was reduced. In practice, however, this would not operate, as the free space would be kept the same by charging a greater weight of the large coal.

Turning to the case where the rate of carbonization is increased by raising the carbonizing temperature, it is found that while the passage of heat from the retort walls to the plastic layer is faster, a difficulty is met with in the fact that the portion of gas which had to pass through the coke and along the retort walls to the off-take pipe is subjected to a larger amount of "cracking," owing to the higher temperature. There is a tendency for a depreciation

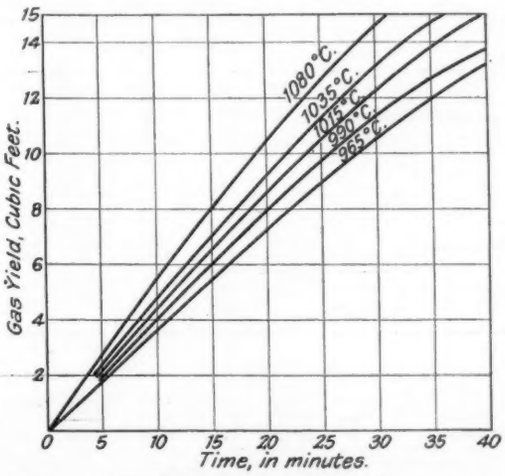


Fig. 4.—Volume and time of gas evolution of the same coal at various temperatures.

of calorific value or of thermal yield per ton which may not be counterbalanced by the benefit obtained by the more rapid carbonization. There is, of course, the extra yield which may be obtained by a reduction of the volatile matter in the coke at the higher temperature; but for temperatures over 950° C. the extra yield from this cause does not amount to very much.

In fig. 4 are plotted the gas yields for each five minutes of samples of the coal of the same size at different temperatures in the coal-testing plant. The coal used contained: Moisture, 0·59 p.ct.; volatile matter, 28·49 p.ct.; fixed carbon, 68·52 p.ct.; ash, 2·40 p.ct. It will be noticed that the gas evolution is regular, and the curve approaches a straight line up to the point where it is evident that the heat has penetrated to the centre of the charge. The reduction in time with increase in temperature is very substantial, but, as shown in fig. 5, falls off when the temperature reaches about 1050° C.

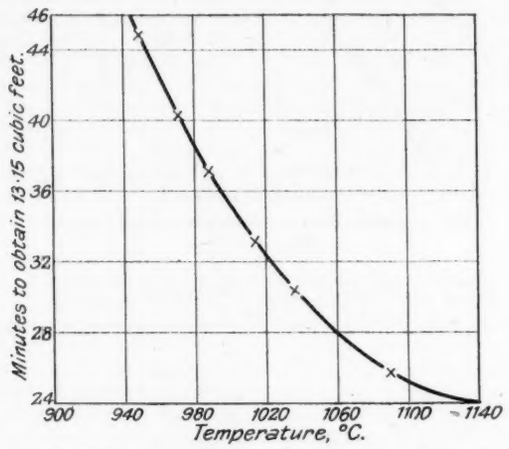


Fig. 5.—Time taken to obtain the same yield at various temperatures.

Two series of experiments with the same coal were made, to illustrate further the effect of increasing the temperature. In one case (A) three charges were carbonized at 950° C. (inside the retort) and in the other (B) at 1090° C. The conditions were maintained as even as possible for each series of experiments, and 13·15 c.ft. of gas collected in each case. In the case of the last charge from the coal at the higher temperature, the carbonization was allowed to run on until an extra 1·85 c.ft. had been separately collected. In order to study the course of carbonization, a sample of the gas for analysis was taken during each five minutes from the inlet or outlet of the condensers. The calorific value and analysis of the total volume of the purified and mixed gas from each charge were also obtained. The carbon dioxide, oxygen, and nitrogen content of the 5-minute gas samples varied little from a total of 3 p.ct.; but the purified gas contained a total of about 5 p.ct. The whole of the analyses and calorific values were therefore corrected to a common total of 3 p.ct. of these constituents. Results are tabulated in fig. 6. appended.

It will be seen that the average figures calculated from the 5-minute samples agree very closely with the average of the holder gas, considering the large fluctuations of the quality and rate of gas evolution. The methane figure calculated for B is evidently a little high. The lower figures for hydrocarbons in the 5-minute samples in comparison with the average sample are accounted for by the fact that in the former case the samples were necessarily drawn off in the presence of tar; while in the latter case the gas and tar have been separated before cooling. As has been previously pointed out, average mixed tar is not in equilibrium with the cooled and purified gas; but the former is capable, if given the opportunity, of abstracting hydrocarbon vapour from the latter.

In the last column of the table, the average calorific value of the gas evolved in each 5-minute period is shown. It falls in the case of A from 723 B.Th.U. per cubic foot to 372 B.Th.U. For the B series, the initial calorific value is lower—699 B.Th.U.; but the final is higher (462 B.Th.U.), even for the "extra" gas. The average of A is 11 B.Th.U. higher than for B by calculation from the 5-minute analysis, and 23 B.Th.U. by calculation from the average analysis. The actually determined values (corrected) were 567 B.Th.U. and 541 B.Th.U. per cubic foot respectively—a difference of 25 B.Th.U. By running on in the case of B till a make corresponding to 15,000 c.ft. per ton is obtained, the average calorific value only falls by a further 12 B.Th.U. The actual course of the carbonization in each case is best illus-

Minutes.		C.Ft. Total.	Increase each 5 Mins.	Unsaturated Hydrocarbons.			Hydrogen and Carbon Monoxide.			Methane.			B.Th.U. Total each 5 Mins.	B.Th.U. per C.Ft.	B.Th.U. Accumulated.	
				P.Ct.	Total C.Ft. × 100.	B.Th.U. at 2320.	P.Ct.	Total C.Ft. × 100.	B.Th.U. at 321.	P.Ct.	Total C.Ft. × 100.	B.Th.U. at 1003.			Each Period. Total.	Each Period. Per C.Ft.
5	A	1·85	1·85	4·3	7·95	184·4	45·0	83·25	267·2	47·7	88·24	885·0	1336 6	723	1336·6	723
	B	2·70	2·70	2 9	7·83	181 6	45·8	123·66	396·9	48 3	130·41	1308·0	1886·5	699	1886 5	699
10	A	3·90	2·05	2·0	4·10	95·1	59·8	122·59	393·5	35·2	72 16	723·7	1212·3	591	2548·9	653
	B	5·70	3·00	2·7	8·10	187·9	66·0	198·00	635·6	28·3	84·90	851·5	1675·0	558	3561·5	625
15	A	5·80	1·90	1·9	3·61	83·7	64·2	121·98	391 5	31·0	58·9	590·7	1065·9	561	3614·8	623
	B	8 30	2·60	1·4	3·64	84·4	65·6	170·56	547·5	30·0	78·0	783·3	1414·2	544	4975 7	599
20	A	7·40	1·60	1 7	2·72	63·1	66·4	106·24	341·0	28·9	46 24	463·8	867·9	542	4482·7	606
	B	10·65	2·35	0·7	1·64	38·0	73·2	172·02	552·2	23·1	54·28	544·4	1134·6	483	6110·3	574
25	A	9·00	1 60	1·6	2·56	59·4	66·9	107 04	343·4	28 5	45·60	457·3	860·1	537	5342 8	593
	B	12·75	2 10	0·7	1·47	34·1	75·1	157·71	506 2	21·2	44·52	446 5	986·8	469	7097 1	557
30 (26)	A	10 50	1·50	1·4	2·10	48·7	67·3	100·95	324·0	28·2	42·30	424·2	796 9	531	6139·7	585
	B	13·15	0·40	0·7	0 28	6·5	75·1	29·04	93·2	21·2	8·48	85 0	184·7	462	7281·8	554
35	A	11·95	1·45	1·3	1·88	43 6	67·7	98·16	315·1	28·0	40 60	407·2	765·9	528	6905·6	578
	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40	A	12·85	0·90	0·5	0·45	10·4	75·5	67·95	218·1	21·0	18·90	189·5	418·0	464	7323·6	569
	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
45	A	13·15	0·30	0·4	0·12	2·8	88·9	26·67	85·6	7·7	2·31	23·2	111·6	372	7435·2	565
	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total or Average	A	13·15	13·15	1·9	25·49	591·2	63·5	834·83	2679·4	31·6	415·25	4164·6	7435 2	565	7435·2	565
	B	13·15	13·15	1·7	22·96	532·5	64·7	850·99	2731·6	30·5	400 59	4017·7	7281 8	554	7281·8	554
Average Sample of Total Volume	A	13·15	..	2·2	..	..	63·4	..	..	31·4	..	..	..	569	..	..
	B	13·15	..	2 0	..	..	66·5	..	..	28·5	..	..	..	546	..	..
EXTRA GAS.																
33	B	15·00	1·85	0·7	1·29	29·9	77·0	142·4	457·1	19·3	35·7	358·0	845·0	456	8126·8	542
Total or Average.		15·00	15·00	1·6	24·25	562·4	66·3	993·4	3188 7	29·1	436·3	4375 7	8126 8	542	8126·8	542

Fig. 6.—Table Showing Result of Carbonizing Coal at Two Different Temperatures in Coal-Testing Plant. Series A at 950° C.; Series B at 1090° C.

trated by curves. Fig. 7 appended shows the total thermal output at the end of each 5 minutes, and also the proportion due to the methane, the hydrogen and carbon monoxide, and the hydrocarbons. The areas marked show the differences due to temperature.

The rates of thermal output and volume output (fig. 8) give the usual type of curve, the characteristic of which is the central flat portion between the initial period and the last period when the heat has penetrated to the centre of the charge. At higher temperature there is naturally a

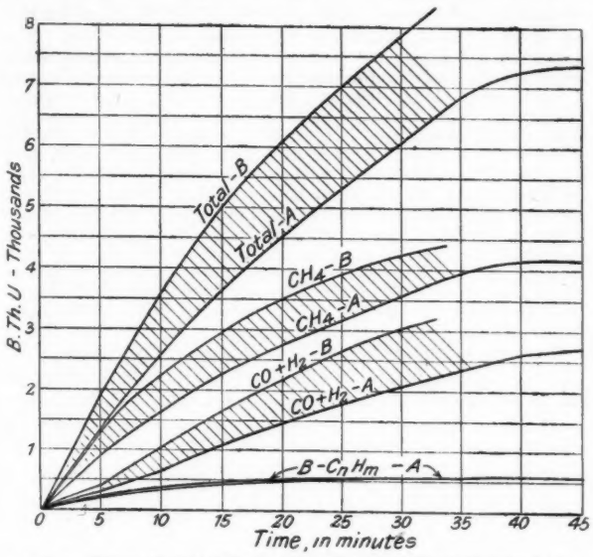


Fig. 7.—Total Thermal Output and Time at Different Temperatures. The lower curves show the thermal output due to methane, carbon-monoxide, and hydrogen, and hydrocarbons. The shaded areas show the difference.

A at 950° C. B at 1090° C.

tendency to shorten the central portion. The curves for thermal output, once the initial period is over, correspond very closely with the volume output; and it follows that similar curves for the calorific value would also correspond. The calorific value of the gas from the higher temperature charges drops more rapidly than that from the lower temperature charge, as is shown by the gradual widening of the area between the curves (fig. 9); but at the same time, the volume of gas from the coal at higher temperature is rising

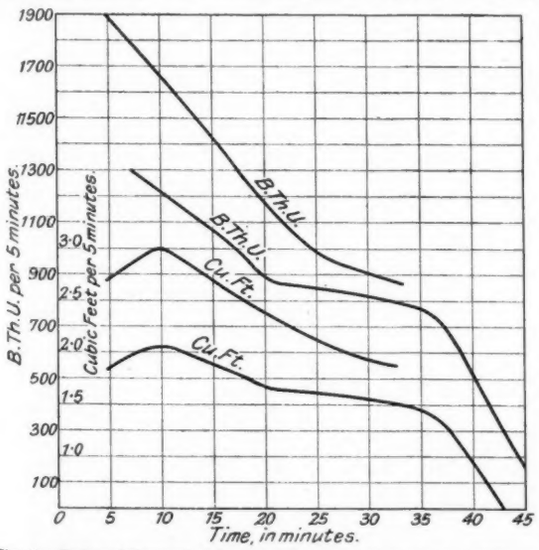


Fig. 8.—Rates of thermal output and evolution of gas for two different temperatures.

just as rapidly till a sudden break occurs, showing that the carbonization is completed at a gas yield corresponding to about 14,000 c.ft. per ton. It will be noticed that the break in the curve for the gas yield at lower temperature occurs at a point corresponding to a little over 12,000 c.ft., and no amount of further heating at this temperature, or even at a higher temperature, will materially increase the gas yield. Reference has already been made to the fact that the last portion of gas evolved has a calorific value of only 372 B.Th.U.

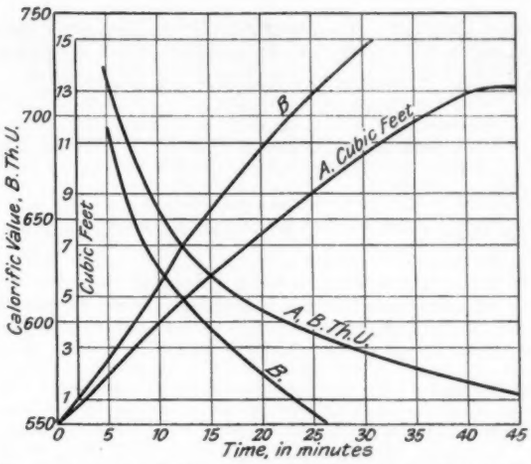


Fig. 9.—Average calorific value and total volume at each period for two different temperatures.

A 950° C. B 1060° C.

Reference to fig. 10, where the accumulated volume of gas is plotted against the average calorific value, shows that, volume for volume, the gas from the coal carbonizing at the higher temperature is slightly above that at the lower temperature until about 9 c.ft. have been obtained, when the curve A crosses B. At the 12-c.ft. mark, the calorific value of the lower temperature gas falls off suddenly, although the coal at higher temperature is still giving a fairly good gas at a consistent rate.

The more important conclusions reached may be shortly summarized as follows:

1.—An increase in the rate of carbonization caused by alteration in the chemical and physical conditions—due for example to the use of a more suitable type of coal, or a more suitable size of coal particle—is accompanied by improvement in the calorific value of the gas and of the thermal and volume yields per ton of coal. Improvement is found in every direction.

2.—Very considerable increase in the rate of carbonization may be obtained by selection of those coals which give up their gas above a minimum rate. Except in cases of oxidized coals, the calorific value of the gas, and consequently the thermal yield, is higher for an increased rate.

3.—When an increase in the rate of carbonization is caused by an increase in carbonizing temperature, the results are complicated by the fact that the portion of the gas evolved on the outside of the plastic layer is subjected to an increased degradation; and this opposes the tendency of the higher rate to give gas of superior calorific value. Up to the end of a certain time, the calorific value of the higher temperature gas is smaller than that of the lower temperature, but, volume for volume, there is a slight balance in favour of the high temperature gas. After a certain period when the coal at high temperature is nearly carbonized, the calorific value falls off very rapidly, while the coal at low temperature is still producing gas of moderate quality.

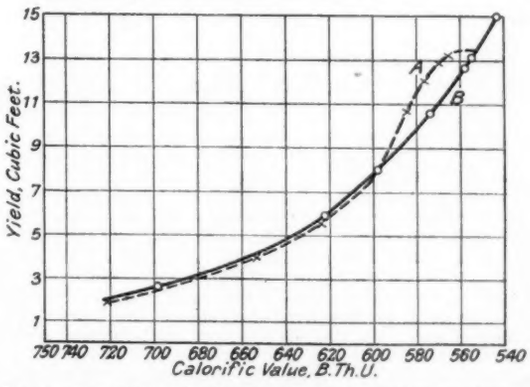


Fig. 10.—Gas yield and calorific value up to each period for two different temperatures.

A 950° C. B 1060° C.

An increase in volume and thermal yields per ton follows an increase in rate due to a higher carbonizing temperature, which it is impossible to obtain at lower temperature.

Volume for volume the calorific value of the higher temperature gas falls off at a slightly greater rate than the lower temperature gas, but a greater volume of gas is evolved from the former, which quickly makes up for the deficiency.

The PRESIDENT: I am sure we are all very much indebted to Dr. Weyman for his paper. All who are interested in the process of carbonization cannot but feel that this will prove to be a very valuable paper indeed. It indicates certain ways in which an increased number of therms can be got from the coal; and it also shows, in one of the tests (where he gives a make, in a test retort, of 15,400 c.ft. per ton, of 530 B.Th.U. gas) that at any rate with one coal—I do not know whether it is ordinary coal or a special coal—he is able to get as much as 81 therms. If 81 therms can be obtained in a test retort, I think we must feel that it can be obtained in an ordinary retort, and we shall have to work for that.

Discussion.

Mr. THOMAS GLOVER (Norwich): I should like to say a word or two on this paper. I think anyone who comes forward with such a paper ought to be thanked and encouraged. The work is tedious, requires a good deal of patience, and a good deal of sustained hard work has to be put into it; and I think we should like to thank the author and those who have worked with him. I can see that there are three chief influences which lead to either the retarding or speeding-up of the carbonizing process. The first is the condition of the coal; the second the shape of the chamber or vessel in which the process is carried out, and the power to apply and pour-in heat units through its walls; and the third is the power to apply convected heat to the incoming charges. If we are dealing with the horizontal system, we are confined to the first two, and the condition of the coal is a very important matter. We know that small coals, dusty coals, are very bad conductors of heat, and to attempt to carbonize thoroughly such coals in the same period that we can carbonize nuts or round coals would mean that we should unduly punish the vessel in which the carbonizing process was carried out. We should probably have a great deal of undue cracking of the hydrocarbons and the formation of lamp black and free carbon in the tar, and so forth; and we should have regard to that in tabulating results of this kind. I expect the experimenters have taken their precautions. I have not read the paper sufficiently carefully to find out whether they kept to one seam of coal in determining these rates.

It is interesting to see how our ideas are altering, how thermal value has entered into this paper to such an extent. It is interesting, and it marks a period. We know, of course, that the coals of Scotland give off their gases much more rapidly than do Yorkshire coals, and particularly more rapidly than Durham coals. We know that Durham coals generally are very refractory, and take more distillation, more heat, or a longer period than do some of the other coals in the country, particularly those of Scotland; and anyone experimenting in this line should pay due regard to this fact. There is any amount of room for experiment to find the mixture of coals that will best suit our purpose, carbonize in the period we wish, and give us the thermal output we seek. I strongly believe that we make a great mistake in receiving dusty coals, because they are such bad conductors in the retorts. I think coal should be graded, and that we should have the advantage of clean, graded coals whenever we can get them at reasonable prices. If the dust is eliminated, it speeds-up the carbonizing considerably, and gives better results in every way. With regard to the shape of the vessel, it has been taken as a rough sort of standard that one hour per cwt. in the retort is about right—*i.e.*, if we had 8 cwt. in a retort it would take 8 hours to carbonize, and 12 cwt. would take 12 hours, and so forth. That is not quite true; it does not stand. We can get 14 cwt. into a 21 ft. retort, and carbonize it very well in 12 hours without unduly punishing the setting, but in the other shape of vessel I tried some years ago, and many of you were interested in it—that is, the rectangular-shaped chamber—we managed to carbonize 21 cwt. in 12 hours as readily as we carbonized 14 cwt. in the ⌂ shaped retort. It depends on the shape of the vessel. The shape of vessel was correct for transmitting heat through the charge. It gave us the least thickness of coal for the reasonable period of carbonization, 12 hours; and because of the transmission through the walls of the retorts and through about 6½ ins. of coal, we were able to accelerate the speed of carbonization. But it seems to me that the vertical system has been a tremendous gain in this matter of speeding-up carbonization, not only because of the shape of the vessel that can be adopted, and is adopted, but because the convected heat passes up in the form of gases, and steam which is ultimately decomposed into gases, and passes through the incoming charge. I think, perhaps, we ought to take note of this fact, that part of the carbonizing in verticals is done by the hot gases passing up from the lower part of the retort. It is a matter of great interest, because we are limited, in our horizontal system, to the absolute passing of heat by conduction through the retort and through the charge; but it seems to me that in the vertical it is possible to pass a great deal of convected heat through the charge, and do a great deal of carbonizing in that way. I shall be much interested in studying the paper more thoroughly; and I appreciate the attempt that has been made to give us these figures.

Mr. C. DRU DRURY (Sunderland): I think we have listened to a most interesting paper. It is a record of painstaking and most careful investigation, and shows the great importance, particularly to those who, perhaps, have not realized it before, of the time element in carbonizing. It also shows the futility of buying coal on analysis only, where the time factor is not shown. This appeals to me especially, as I have often had difficulty in reconciling practical results of carbonizing coal with the results obtained in coal-testing plant. It is true that in recording these results we record the period taken to burn-off that coal; but one does not seem to appreciate this fact when it is simply shown in a few minutes more or less. Probably the better plan would be to have an exactly fixed period for carbonization, and to stop the coal-testing results at an absolutely clear technical period. So far as the size of the coal is concerned, we have probably all had experience in that direction. The undertaking which I represent buys exclusively unscreened Durham coal, and we often get 30 p.ct. through an 8 mesh. If there has been any difficulty in getting the coal we have had nuts sent in, and we have realized at once the difference in carbonizing. I do not wish to take up any more time, except to express my sincere thanks to Dr. Weyman, and to assure him that this paper will be studied carefully by most of us.

Dr. R. LESSING: I should like to ask Dr. Weyman whether he has found any explanation as to why the rate of carbonization varies according to the size of coal. One explanation, given by Mr. Glover, is that a smaller coal is less conductive than a larger coal; but it is one, I think, which will hardly hold water. I should rather imagine that the more you filled your retort, and filled out the voids in the retort, the more conducting the mass must be, however little conducting the coal itself is. I should like to offer as an explanation that it might be possible that the mere contact action plays a part—that is to say, with a smaller coal you offer a greater surface to the gases than with a larger one, a greater outer surface. In carbonizing we have to consider that we are not dealing really with gas in the first instance, but with a mixture of gas and very heavy vapours. This is a fact frequently lost sight of—that we do not develop purified gas inside a retort, but we have to deal with tar and any pitch vapours; and these vapours are really the gas-making constituents, much more than the gas primarily released from the coal. In heating up—and this is a point to which I have drawn attention several times lately, and also in the discussion on Sir George Beilby's paper, which was read only a few weeks ago—we have to deal with a condition of things in which only, as Dr. Weyman stated, the coal in actual contact with the retort wall is carbonized immediately at a high temperature. The remainder of the charge, and the whole of the interior of the retort charge, undergoes a very gradual carbonization; and whatever our views may be on the question of low-temperature carbonization, we cannot close our eyes to the fact that even where the higher final temperatures are being used we go through a course of low-temperature carbonization in every case. In the course of that carbonization, the tar vapour and pitch vapour released in the hotter parts of a charge are condensed in the inner and cooler parts, to form a mixture of coal and tar, a solution of coal and tar, or tar in coal; and it is really this material that is, by-and-by, being subjected to carbonization. It is not the original coal at all. This is a material containing a very much higher percentage of gasifiable volatile matter; and the conditions change at the rate at which the temperature penetrates the interior of the coal charge. If we have comparatively large particles, which also involve comparatively large spaces between them, it is first of all easy for the gas and vapour to escape, because there is very much less resistance, and they can be drawn from the retort in a comparatively short time, but also the condensation effect would be a somewhat smaller one. On the other hand, with smaller particles, the condensing effect of the tar vapours on the coal itself has added to it a certain scrubbing effect, which is not pure condensation by temperature actions, but scrubbing brought about by the impinging of the tar vapours on the smaller particles; and you get a clogging, which prevents the gas from escaping regularly. We, therefore, get a very much denser mass in the centre of the retort, which, when finally subjected to higher temperature, undergoes these high temperature actions which lead to the liberation of the gas. We then make a larger volume which consists largely of broken-down hydrocarbons, enlarged by reason of having a higher hydrogen volume—a good deal of the carbon constitution of the hydrocarbons is thrown down and turned into ordinary retort carbon, in this way increasing the weight of coke. I should like to suggest to Dr. Weyman that possibly an examination of some of the differences observed between the large and small size particles might be useful. The other matter, of course—of higher initial temperature and lower later temperatures—is one of great interest, and is merely a question of actual results. But one thing should not be lost sight of, and that is, though the final result may be the same, especially if an extra kick is given to the high temperature, it is still a question

whether the leaner gas you thereby produce is really more desirable. We have the case where you have equilibrium in the course of condensation between the heavy hydrocarbons and permanent gases; and it is a question there whether one should not aim at the point where these hydrocarbons are not unduly destroyed. I should like to add my congratulations to those of the other speakers who have expressed their appreciation of the work done by Dr. Weyman. From my own experience I must say the work involved in the preparation of papers of this kind is tremendous, because one table, which is explained in a very few minutes here, will take months and months to construct, consider, and eventually to give.

Dr. A. PARKER: There is just one thing I should like to ask. In the paper it says that "temperatures taken of the gas leaving the retort were shown to rise up to 100° C. higher than when more easily carbonized coals were being dealt with," and it goes on to say that this is distinct evidence of a large proportion of gas passing up the retort walls. I should like to ask if the percentage of moisture in the coal discharged has been taken into account, because I gather from the paper that in this particular point we are dealing with continuous vertical retort work, and, as we know, we first get the moisture driven off by the gases travelling through, and then a low-temperature carbonization, and gradually increase the temperature. If the coal contains larger quantities of moisture, then obviously the gases leaving the top of the retort will be very much cooler as the result of the latent heat of evaporation; and that is a point which ought to be taken into account before coming to conclusions as to whether the high temperature is due to the gases travelling against the walls of the retort, rather than through the centre. With regard to the experimental retort, it would have been interesting to have had the dimensions, because, as we know, the dimensions and shape and the exact position of heating in the retort, especially a small retort of that kind, might have a very great effect on the actual results of carbonization. It would be interesting to compare the results obtained in such a retort, with a particular coal, with the results secured on a large scale in (say) continuous vertical retort work and in horizontal work. The results in the experimental retort might not be equivalent to those obtained on the large scale. With regard to the composition of the retort, it would be rather interesting to know whether the ends of the retort had shown signs of depreciation as the result of the formation and decomposition of nickel-carbonyl, resulting from the interaction of nickel and carbon monoxide. Has any depreciation of the retort been observed as the result of any action of this kind?

Dr. W. B. DAVIDSON (Newcastle-on-Tyne): The facts put forward by Dr. Weyman apply to continuous vertical retorts, and we must make up our minds as to the theory of carbonization. Horizontal retorts do not labour under any difficulty in the matter of the plasticity of coal; but in continuous vertical retorts, and more especially in low-temperature carbonization, the plasticity of the coal is a very important factor. I think it will be acknowledged that there are certain coals which are so strongly caking, or so strongly plastic, at certain temperatures that it is impossible to carbonize them, even when you have (say) water gas passing through the retort all the time. I do not consider Dr. Lessing's explanation fully meets the case, because, if his explanation is correct, you would expect that a current of gas passing up through the retort all the time would carry away any carbon formed, and prevent it from condensing in the coal. But in spite of this, you do get plasticity, rendering it almost impossible to carbonize the coal satisfactorily. I must thank Dr. Weyman for the enormous amount of work he has done in connection with this very important subject. With regard to the figure of 81 therms, I think it is possible, when you consider that some of the coals contain only 4 p.ct. of ash, which is very unusual for coals.

Mr. W. W. TOWNSEND (Colchester): There is one point which does not seem to be sufficiently emphasized, and which arises out of the shape of the retort. I want particularly to direct attention to the work which has been done by Mr. Thomas Settle. He had some very interesting tables showing the periphery of the retort, and the rate at which heat was transferred per unit of length. If you take any sectional figure, that section in which the periphery is the greatest in proportion to the area is the best for carbonizing, and that is a parallelogram; and the very worst would be a circular retort in which the periphery was the smallest possible, because you have to pour the heat in from the outside, and the greater the periphery the more heat you can pour in in a given time. It would be very interesting, in connection with an investigation of this kind, if some figures as to that factor of periphery and the heat units passed into a vessel of any given size were included; and I think investigators would do well in this connection to look up Mr. Settle's figures, which are very elaborate. They deal with vertical retorts, though not the continuous vertical type.

Mr. T. F. E. RHEAD (Birmingham): I should like to thank Dr. Weyman for his very valuable paper. I think this method of attack, of systematic small-scale experiments, co-related with large-scale work, is just the thing we are asking for; and the more experiments we have on these lines, the better for the industry. I might emphasize the fact that it is extremely difficult to co-relate small-scale experiments with large-scale ones. I should very much have liked to have seen more details of the experimental method and apparatus adopted—such as the method of control of temperature, position of burner, and so forth. I assume from the paper that Dr. Weyman used an optical pyrometer fixed on the exterior of the retort. It is interesting to note that I recently obtained as much as a 10 p. ct. increase in the thermal output of a coal during the normal carbonizing period, after the fines had been eliminated. Dr. Weyman, in speaking of oxidized coals, referred to weathered coals. An interesting series of experiments on coals that have been out in the weather for various periods appears possible in this apparatus. During the coal strike last year, I had occasion to use some American coal in vertical retorts. I got over the difficulty of carbonizing this American coal, which gave a very dense coke in vertical retorts, by mixing it with 10 to 20 p.ct. of sawdust. This was purely an emergency measure, and is not to be recommended for ordinary purposes, as it makes the coke very dirty.

Mr. F. J. BYWATER (Newcastle-on-Tyne): I have read this paper, and it seems to me to be full of points which require careful attention. I think it is a very appropriate time for a paper such as this to be brought before the Institution, when we are in the process of going over to the system of charging on the therm basis. I notice that Dr. Weyman puts his results forward in therms, and my experience tells me that the amount of gas evolved should be stated in therms and not in cubic feet. There are many coals which will give approximately the same number of therms per ton as other coals, at 2s. or 3s. per ton less, in round figures. But I want to emphasize the fact that now we are selling in therms, we should value our gas coal in therms. The question of using large or small coal has been raised. If you ask your coal supplier to give you a screened coal, he wants to know what to do with the fine coal, and you have to pay more for the screened. The question is, What is it worth? I should have liked to have had more details of this plant on which the results in the paper were obtained, because my experience goes to show that a lot depends on the plant. The cracking space in the roof of the retort has an enormous effect on the value of the gas. My experience is that the better the retort is filled up, the better the results will be. We have always been given to understand that uneven charges are bad. I should like to pay my tribute to Dr. Weyman for his paper.

Dr. R. LESSING: As to the question of fine coal, I take it that the smaller sizes, as compared with the larger sizes, always represent identically the same coal in these experiments, because in that case, of course, we must always consider that the smaller coal, representing the very friable portion of the total seam, is of entirely different composition from the larger lumps and larger quantities. We have in it a very considerable amount of fusain, which is not coking at all, and also, of course, a very large percentage of ash. I want to be certain that in this case it was merely a question of size.

Dr. WEYMAN, replying to the discussion, said: On the question of the variation of the coal, in these coal tests I have not used one particular seam, because, as a matter of fact, unless you are a friend of the colliery manager, you will find it very difficult to get samples from one seam. It is the custom to work several seams at most pits, and these seams comprise, perhaps, a gas coal, a coking coal, and a steam coal; and they are all mixed. For the purpose of my examination I took a sample which served me for the series of tests. This sample was a picked one, and that is the reason the ash content is low. It is significant in this way, that it shows what can be done in reducing the ash content, if the collieries would only go to the trouble. Some of the coals have what you might call an intrinsic ash content of only about 1½ to 2 p.ct.; but we never find that with the average sample we get at the works. The shape of the vessel is, of course, a very important item; but my object in this important study was not a question of getting the heat from the producer or furnace into the charge, but of getting the heat from the surface of the retort through the coal, so that I have not really taken into consideration the external shape of the vessel. It is a constant in each case, and exactly the same retort was used for all the experiments. I have not the actual dimensions of the retort; but these tests are all comparative one with the other. They are not absolute measurements. Mr. Drury referred to the unscreened coal we usually get. The term "unscreened" is a commercial term; but I am afraid that in very many cases it has been screened and then re-mixed. We very often find that variations exist not only from truck to truck, but from the top to the bottom of the truck. [Laughter.] Very often the amount of dust is extraordinary. Some coals are naturally soft; and even if the collieries did size them, some coals would give you more difficulty at the works than others. Dr. Lessing referred to the theory of conduction. [In referring to Mr. Glover's remarks on conduction, I take it that Mr. Glover meant the transmission of heat.] I should judge that very little heat penetration takes place by conduction through the plastic layer when first set up. When fine coal is first put into the retort, you have the actual contact. The fine, as could be seen from the slides, gave a very rapid rate for the first few minutes, due to the extra surface it would have when it came into contact. The larger coal took several minutes to recover, because it did not make contact with the retort to the same extent.

Once that initial period is over, I should imagine the major portion is transmitted by convection currents, because the plastic layer is non-conducting and very resistent to gas pressure. I am very doubtful whether the carrying into the charge of tarry matters, and their deposit towards the centre, takes place to any great extent, because the gas is evolved from the exterior of the plastic layer, and the temperature drops through that plastic layer are very great. It is more a question of liquation or of the dissolving of the particles of coal; and, naturally, it is very much easier for the small particles to get into a semi-liquid condition than for the large particles, and it is very much easier in that case to get a continuous and regular layer. Where you have large particles you get bigger passages through the layer; and some of the most rapid tests I have made were not so much when it was one standard grade size as when it was a very irregular mixture, where, you might say, the probability is that the passages were considerable in certain parts. The question of whether it is preferable to use an increased temperature to get increased rate is a problem we have been up against for a very long time; and while the degradation does not go down anything like what one would imagine, the quality of the gas is maintained much better than you would expect as you raise the temperature. Yet, of course, it is always a point as to whether it is worth while sending out the inferior quality. Fortunately, if you can increase the rate by other means mentioned, you are on the safe side, because the calorific value of the gas is higher. The sampling down of the coal for the purpose of these tests presented a very considerable difficulty in getting an analysis of each grade exactly the same. The process adopted was to pick lumps out and divide them into a certain number of grades, each of which was brought down to a certain size. It was not then absolutely accurate; but you will see from the notice in the paper that the approximate analysis comes within very close limits for different sizes. Dr. Parker raised the question of the moisture content of the gases as possibly accounting for the higher temperature which was noticed at the gas outlet of the large-scale retorts when more easily carbonized coals were being dealt with. They were, of course, vertical retorts, and, as a matter of fact, the moisture content was very low, because there is no water supply. The coal is not wetted at the top—in fact, it is dry. I think you can take it that the moisture content is very low, there being only about ½ p.ct. of moisture in the coal when it goes into the retort. I have not observed any deterioration of the nickel-chrome steel at the ends of the retort; but there is a small amount of scale on the interior surface at the hot end. It seems to be, and probably is, nickel-carbon-iron. This retort has been in daily use for several months, and you cannot observe any effects at all beyond a little scale which comes off with the scurf. Dr. Davidson spoke of carrying of heat by steam and vapours in vertical retorts, and there is no doubt a considerable amount of heat is transferred in this way; but it depends very much on the coal which is being used. I think the effect is most marked where you are using a coal which is of a cannel type; but if you use bituminous coking coal, you will not get the benefit which you might anticipate. As to the shape of the retort, there is no doubt that such an investigation would be most valuable. The temperature control of the retort was by means of an optical pyrometer, focussed, first, on the inside of the retort before the coal was inserted; and we took readings on the outside of the retort through an opening throughout the period of the charge. As to the oxidized coals I referred to, perhaps my remarks were rather ambiguous; but they are weathered coals in this sense, that they are usually near the surface, and are coals which are used more for steam than for anything else. They are not weathered in the sense that they are stocked coals left out in the open. I am very pleased that Mr. Rhead noticed the increase of thermal output due to the elimination of fines, because I have not been able to measure any definite or actual advantage. We know it is there, but we cannot assess it at anything like 10 p.ct. However, I am very pleased that Mr. Rhead can give 10 p.ct. as being a possibility. This amount will depend upon the composition of the coal to start with. I thank you very much for your attention.

The meeting adjourned for luncheon.

NATIONAL GAS COUNCIL.

Meeting of the Central Executive Board.

A Meeting of the Central Executive Board of the National Gas Council was held on the 19th inst., with Mr. D. MILNE WATSON in the chair.

DAMAGE TO MAINS BY HEAVY TRAFFIC.

Mr. Walter Hole (the Chairman of the Committee appointed by the Council to consider the question of damage to mains by heavy traffic) gave a full account of the proceedings of the Committee. It was decided that an attempt should be made in future legislation to cope with the increasing difficulty which was being experienced in gaining access to gas-mains by reason of the increase in the number of underground structures.

COAL MARKETS.

Views were interchanged as to the present position of the various coal markets, and the probable future movements.

RATING ASSESSMENTS.

An interview was reported with the General Manager of the Machinery Users' Association (Incorporated) on this matter.

LIGHTING IN FACTORIES AND WORKSHOPS.

It was stated that the report of the Joint Committee of the Institution of Gas Engineers and the British Commercial Gas Association upon the Second Report of the Departmental Committee on Lighting in Factories and Workshops had now been received, with special reference to the Departmental Committee's recommendation regarding the prevention of "glare." The Joint Committee considered that this recommendation needed to be modified, and submitted their views to the Departmental Committee. It is understood that the Third (and Final) Report, which is now being prepared by the Departmental Committee, will contain a modification of the recommendation in question.

SAFEGUARDING OF INDUSTRIES ACT—GAS-MANTLES—PART I.

It was reported that the Referee appointed under the above Act had now made his award with regard to the inclusion of gas-mantles in the Schedule to Part I. of the Act. Unfortunately, the Referee had departed from the unequivocal judgment of the Lord Chief Justice as given in the Divisional Court, and had adopted the "ingenious alternative" which the Lord Chief Justice had stated that he ought not to do by introducing the ambiguous phrase . . . "That the list (of dutiable goods) be amended by including therein mechanical aggregates of oxide of thorium and oxide of cerium and of nitrate of thorium and nitrate of cerium, being ingredients of incandescent gas-mantles." This means that a duty will be imposed upon thorium and cerium as being ingredients of incandescent gas-mantles.

The Chancellor of the Exchequer has stated in the House of Commons that the position is as follows: "Pending authoritative determination of the value of these ingredients, delivery is being allowed, if the importer so desires, on deposit of a sum equivalent to the duty on a value of 25 p.ct. of the value of the complete mantles, subject to any adjustment that may prove to be ultimately necessary. In these circumstances, it is not possible to give any reliable figure of the actual duty so far collected." The Council will now take steps with a view to obtaining a lower assessment of the value of the thorium and cerium contained in these gas-mantles, as it is thought that the 25 p.ct. on which the Customs base their calculations is a gross overestimate.

SAFEGUARDING OF INDUSTRIES ACT—PART II.

The views of members and the general position were reported with regard to the application of the Incandescent Mantle Manufacturers' Association for the imposition of a duty under Part II. of the Act in respect of gas-mantles imported from Germany. A resolution was passed re-affirming that the free import of gas-mantles was essential to the industry.

CORPORATION PROFITS TAX.

It was reported that the Chancellor of the Exchequer had promised to extend the exemption of public utility undertakings from the tax for a further three years in the Finance Bill now before Parliament. An amendment, however, had been put down by certain members of Parliament, the effect of which would be to reduce the period of exemption from three years to one year. It was decided to oppose this amendment, because it was felt that any reduction in the period of exemption would increase the difficulty of raising new capital.

A further amendment restricts the exemption to those cases in which an undertaking is not "trading beyond its statutory obligations." Strong exception is taken to this amendment, which would penalize not only those gas undertakings which work-up their own residuals, but those also which supply cookers, fires, and other appliances on hire to their consumers. It was felt that the amendment would exclude practically every statutory gas company; and the Council propose to take the necessary steps to oppose this amendment, providing that such amendment is not ruled out of order by the Speaker, which well may happen.

MODEL BILL.

The Committee appointed by the Council last year were re-appointed with power to co-opt; and it was agreed that this Committee should be called together at an early date to consider and formulate amendments to the Model (Gas) Bill for submission to the Lord Chairman.

American Gas Association.—Readers of the "JOURNAL" who have correspondence with the American Gas Association or are visiting New York will be interested to learn that their headquarters are now at the Canadian Pacific Building, 342, Madison Avenue, New York City. It is a modern building on the South-West Corner of 44th Street, and Madison Avenue is within a block of the Grand Central Station and convenient to the Pennsylvania Terminal. We have no doubt that anyone visiting New York will find it will be a pleasure to the officials of the Association to render them any assistance desired.

RECONSTRUCTION PROBLEMS AT BECKTON.

By W. B. LEECH,

Engineer, Beckton Station of the Gas Light and Coke Company.

It is perhaps advisable in the first place to explain that so much reconstruction work has been carried out at Beckton of late years that, in order not to weary members in considering the subject, a choice had to be made by the author between two methods—either to enter into details about a part only of the new work, or to aim at giving a general description of what has been done, and to state the reasons which dictated the policy. The latter course has been chosen.

The Beckton works were built in 1870, and the original lay-out consisted of twelve retort-houses with a very complete coaling scheme. It was intended, as extensions became necessary, to continue the general design in the form of a horseshoe, with all the condensing, purifying, and other plant housed within. The scheme was excellent, and if hand-fired retorts and low wages had continued, the original idea might have been completed. But times changed. The first departure from the plan was taken when retort-houses Nos. 13 and 14 were placed close to the foreshore, to reduce the cost of haulage of coal and coke. Further causes of change have been: First, the fact that modern methods have enabled the original gas-making capacity of the retort-houses to be doubled or trebled; and, secondly, the introduction of oil gas has, of course, considerably modified the general outlook. The area of the works, situate on the north bank of the Thames, sufficiently near the mouth of the river to permit the direct discharging of seaborne coal, is approximately 245 acres. The gas-making capacity, at the time when the reconstruction work now described was decided upon, was 70 million c.ft. per day.

The principal reconstruction work carried out during the last three years has consisted of:

1. The provision of a new unit of carbonizing plant inside the shell of No. 7 retort-house; the unit to supply 6 million c.ft.
2. Redesign of the producer-gas generators in other retort-houses (260 producers in all).
3. New coal and coke handling plant for No. 7 house.
4. Extensions to the purifying plant.
5. Provision of an extension to the oil-gas plant of 12 million c.ft. per day.
6. Erection of new engineering and wagon-building shops.
7. Provision of new water supply and filtration plant for the same.

Carbonizing Plant.

In deciding upon the type of carbonizing plant to be installed, consideration was given to the following points:

1. Locality.
2. Class of coal obtainable.
3. The market for coke.
4. Site and ground space available.
5. Existing facilities for handling coal and coke.
6. Working results.

Owing to the isolated position of the Beckton works, the question of locality did not influence the choice of plant to any great extent. The class of coal was an important factor, since practically the whole of the supplies are obtained from the Durham district. While it is acknowledged that certain classes of Durham coal are suitable for continuous vertical retorts (which have been very much favoured of recent years), it would be almost an impossible task, when purchasing the one million tons a year required for Beckton, to ensure that it would all be suitable for this type of plant. Therefore, in the circumstances, the choice lay between horizontals, intermittent verticals, and coke-ovens.

A balance-sheet was drawn-up of the estimated working results of the three systems. The coke-oven scheme proved the most attractive from the money point of view, being about 1d. per therm cheaper than the verticals, which came next in order of cost; but this advantage, which was chiefly due to the better quality of coke produced, was discounted by the uncertainty as to the market for this class of coke in the London area. The choice between horizontals and intermittent verticals was a more difficult one. The yield of 75 therms per ton gives a decided advantage to the verticals from the gas-making point of view; but the lower return for residuals per 1000 c.ft. reduced this advantage considerably. The net result, after adding capital charges, is so near the figure given by horizontals, that the adoption of a type of plant new to Beckton was hardly justified.

After arriving at a decision in favour of horizontal retorts, many details remained to be settled. The question of site was fixed by the fact that No. 7 house was the only one which could be spared at the time; and the author will deal generally with the plant installed in it, and at the same time describe briefly the alterations made to the other units of carbonizing plant.

General Description of Plant and No. 7 Retort-house.

In order to reduce labour costs, it was decided to work 12-hour charges with a 23 ft. retort capable of carbonizing

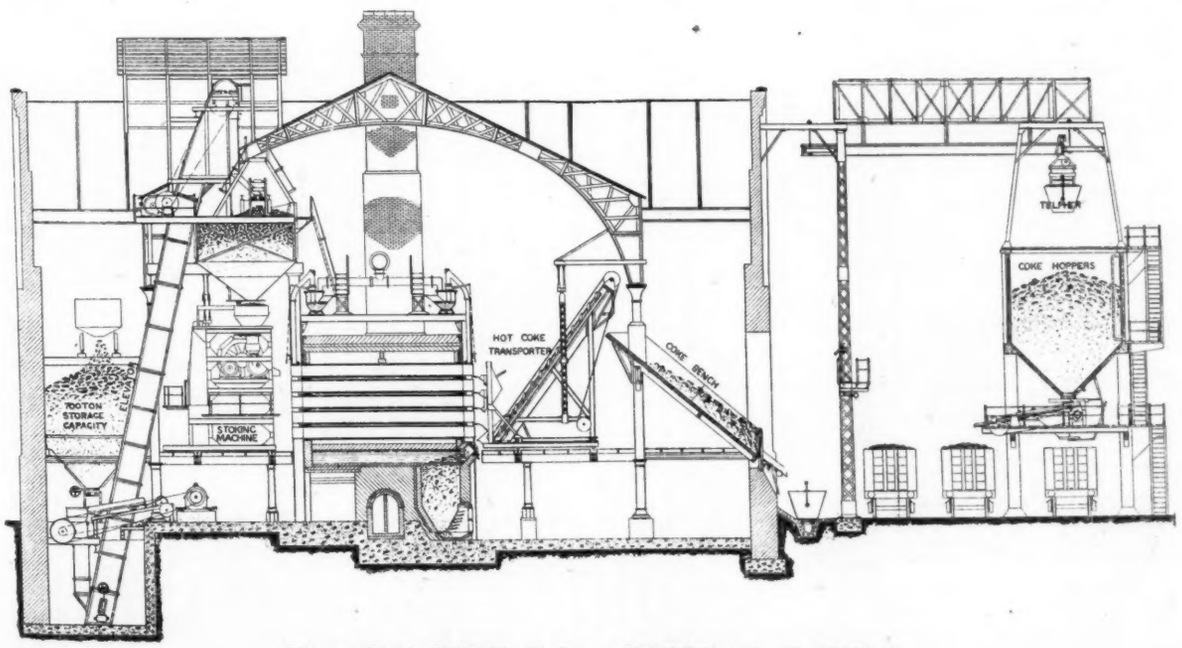


FIG. 2.—CROSS SECTION OF No. 7 RETORT HOUSE AT BECKTON.

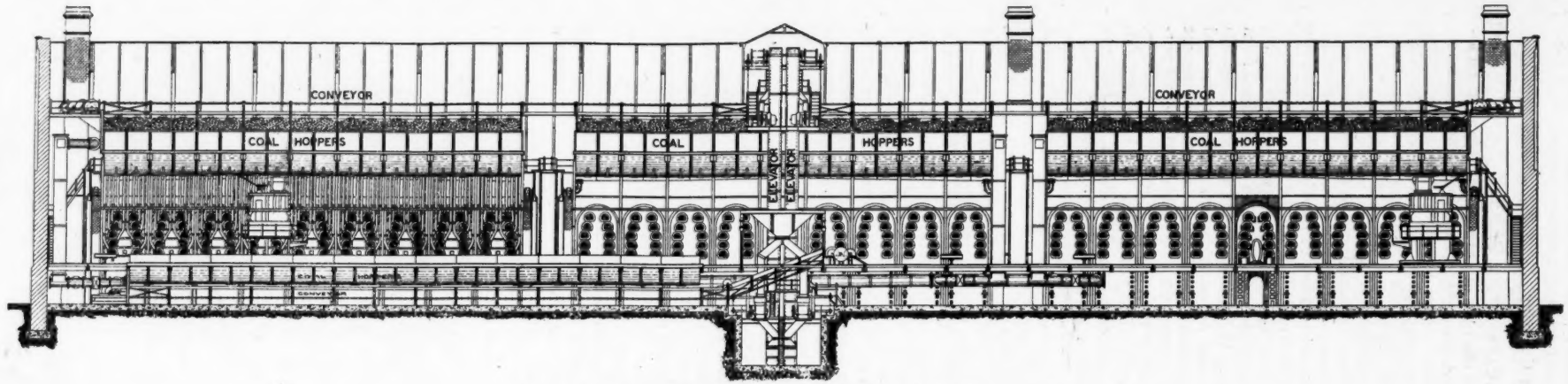


FIG. 3.—FRONT ELEVATION OF No. 7 RETORT-HOUSE AT BECKTON.

20 cwt. of coal; the idea being at the time to work two shifts only. Owing, however, to the easier arrangement of the work, and the fact that there was only a very slight difference in the costs, it was afterwards decided to work three shifts.

Retort Materials and the Selection.—Experience with a 24 in. by 18 in. D-shaped retort in the more modern houses led to the adoption of this section for the No. 7 plant. It was felt that with a machine capable of putting in a charge equal to about 75 p.ct. of the area of the cross-section, thermal results equal to those obtained from smaller retorts could be expected; and, in addition, a decided advantage was anticipated in respect of labour costs.

In order to burn-off the charge in the time fixed, and obtain a full yield of therms, it has since been found that a combustion chamber temperature of 1400° C. is necessary. This is perhaps somewhat on the high side for fireclay retorts, and silica retorts would undoubtedly have been more suitable; but the experience with them at the time, though very promising, was not sufficient to warrant their selection for so large a plant. It may be said, in passing, that acting upon the experience gained in several experimental settings, it has now been decided to adopt the silica segmental retort as the standard.

It is difficult under working conditions to assess the superior conductivity of silica. Individual readings vary considerably—due, no doubt, to the fluctuations of temperature in ordinary inside producers. An average of many readings, however, has given the difference between combustion chamber and retort temperature of 260° C. for fireclay and 200° C. for silica retorts. The advantage of 60° in the retort for the same combustion chamber temperature is a material one.

When settling upon 23 ft. as the length of the retort, no difficulties were anticipated. This length had been satisfactorily proved at other works; and up to the present no trouble has been experienced at Beckton. Retorts of this length are charged and discharged quite as easily as are the 20-ft. retorts.

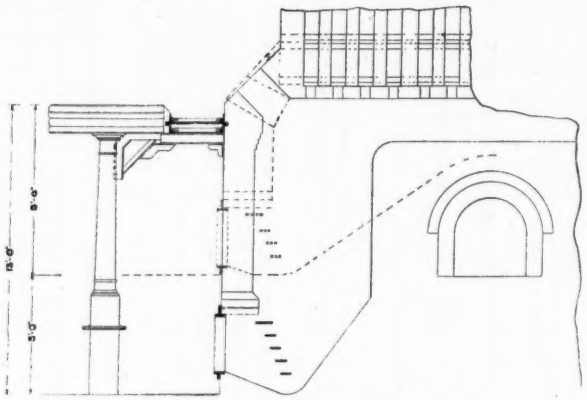


Fig. 5.—Deepened Producer (old type shown dotted.)

Retort-Settings and Producers.—The settings and producers follow in most respects the usual Beckton design, the only notable exception being the depth of the producers. The question of deepening the producers was decided upon after several experiments had been made in the existing houses. A start was first made in No. 1 retort-house, where the furnaces were deepened to the extent of 18 in.—*i.e.*, from 8 ft. to 9 ft. 6 in. It was considered inadvisable to go deeper on account of the danger of flooding, consequent upon the proximity of Beckton to the river. As the results were encouraging and no flooding was experienced, the producers in one section of No. 9 house were deepened by 3 ft. 6 in., this dimension being fixed by the level of the foundations.

It was found that the temperature of the combustion chambers in this section could easily be maintained at an average of 100° C. higher than that of the unaltered section; and it was then decided to deepen the producers in all the other houses by 5 ft.—to 13 ft. in all, as shown in fig. 5. This meant cutting away and rebuilding the foundations—a somewhat expensive task, but one which has given an excellent result. It has been possible to maintain without difficulty a combustion chamber temperature of 1325° C., or an average of 200° more than that with the original producers. This extra temperature has enabled the carbonizing capacity of some of the existing houses to be increased by as much as 25 p.ct.

Again, with this alteration, the necessity for spiking the fires has been done away with; and a house of 30 settings is now dealt with by two firemen per shift, and at less cost than prior to deepening the producers.

Retort Benches—Insulation and Construction.—The front walls of the setting are insulated by a course of asbestos bricks, 2¼ in. thick, and at the top of the bench there is one 3-in. course of insulating bricks. It may be of interest to note that the elaborate arrangements for insulating benches (reported as having been tried in some of the American gas-works) have not proved successful, and were discarded, chiefly

on account of the explosions which occurred at the back of the plating.

A point which may be of interest in connection with the main arches is that the springing line of each arch is raised by 3 in. towards the centre of the bench. This is to allow for the settlement which usually occurs, curtailing the flue space over the top retorts.

It is, of course, well known that, in order to allow for expansion, clearances should be left between the bench and the retort-house staging and walls; but the fact that there is a considerable movement of the foundations is sometimes missed. A clear space of at least 9 in. should be left between the ends of the bench foundations and the foundation of the gable walls of the house. Also, if the chimneys are placed at the ends of the house, then at least a 6-in. clearance for expansion should be left in the roof. The author has seen chimneys badly cracked through this allowance not having been made. Similarly, allowances must be made if the ground floor is paved—more especially in the case of a concrete floor.

Steaming Horizontal Retorts.—With the acceptance of the principle of filled retorts, attention was given to the question of steaming. Tentative experiments in the past had failed to equal the decidedly good results given by vertical retort systems. An auxiliary hydraulic main at the discharging end of four retorts in one of the houses was coupled to an experimental plant, and a series of experiments made with and without steam. With 10 cwt. charges, a temperature of 1250° C. in the combustion chamber, and superheated steam admitted during the last 2 hours through the mouthpiece lid at the rate of 120 lbs. per hour per retort, no increase in therms could be detected. The gas analysis failed to reveal signs of water-gas production. The average therms per ton were within a decimal point of each other.

During the coal strike, all the retorts in one house were fitted with steaming arrangements; and although very large charges were put in, the results did not indicate any advantage. A further experiment was made with four channelled retorts. These, however, failed to withstand the action of the pusher.

Bench Fittings.—With the introduction of the projector type of charging machine, laying heavy charges, double ascension-pipes become more necessary. No. 7 house is so fitted; the pipes being 7 in. diameter.

The standard existing in the "West" houses was 7 in. single pipes on all retorts except the five-high, which were fitted with double 7 in. pipes. To instal double pipes on all the retorts in these houses meant, owing to the fact that the beds were only 10 ft. centres, the adoption of 6 in. pipes throughout and new hydraulic main covers. With the prices ruling, this was considered prohibitive, and a compromise was adopted. A second 7 in. pipe was fitted to the four-high retorts, there being just sufficient room to fit the dip-pipes in the hydraulic main. The three-high retorts having pipes on alternate sides of the bench, it was possible by means of a special Y branch to use the existing ascension-pipes to serve both mouthpieces on each side of the setting. This arrangement (which has proved entirely satisfactory) could, of course, only be used where the retorts are discharged in rows.

The alteration provided 60 p.ct. of the retorts with double ascension-pipes; and the occasional need for "rodding" the two bottom rows is so small that no additional labour is employed.

Congdon Pipes.—Two settings of 10 retorts in No. 1 retort-house were fitted with Congdon pipes; the author's primary object in installing these being to form an opinion as to their labour-saving value. From this point of view, however, he is unable to recommend the extension of the system. Possibly, with a setting specially designed so that the horizontal connecting-pipes are as short as possible, the results would be more satisfactory. Unfortunately, as it was not possible separately to meter the gas, the other advantages claimed for the system could not be ascertained. The separation of the tar and liquor is no easy matter; and the pumping plant for circulating the liquor would be rather cos tly in a large installation.

Automatic Tar Run-off.—This apparatus consists of a tar-tower connected to the hydraulic main in the usual way, but with a special device fitted internally. An upright 6-in. pipe, with the lower extremity supported about 9 in. from the bottom of the tar-tower, and the upper portion forming a cup, extends to the top of the tower, where a tight joint is made. From the cup a connection is taken through the side of the tower to the tar-pot. The level of the top of the pipe may, in effect, be varied (to suit the specific gravity of the tar) by means of a screwed sleeve, operated by a rod or key passing through the top cover.

The surplus liquor flows away through the usual weir valve and sealed outlet, which also regulates the level of the liquor in the hydraulic main; and an equalizing vacuum service connects the latter with the tower. Within a considerable range of specific gravity, the column of tar and liquor in the tower balances the column of tar in the inner pipe, and the tar flows away as made. The device has been found to answer well, keeping the mains clear and assisting in the reduction of the water content in the tar.

Anti-dip Pipes.—There has been much discussion as to the merits of dry mains; but the writer is of opinion that an anti-dip valve is necessary to ensure the best working. No. 7 house is fitted with Cort's patent anti-dips. The valves have worked very satisfactorily with the exception of occasional sticking; but he thinks if fitted with a rod instead of a chain, this difficulty would be overcome.

Dry mains without anti-dip valves have been tried in some of the existing houses, but the practice was discontinued after extended trial, chiefly owing to a peculiar action which took place. It was a common occurrence, when the retorts were open, for a considerable flare of gas to be issuing from one ascenion-pipe, while there was a pull on the other pipe next to it—both being connected to the same hydraulic main.

RETORT-HOUSE STOKING MACHINERY.

The various types of stoking machines which are working, or have worked at recent times, at Beckton include Arrol-Foulis, operated by hydraulic power with Hunter-Barnett pushers, West's scoop chargers and separate pushers driven by compressed air, Fiddes-Aldridge simultaneous charging and discharging machines electrically operated, Guest-Gibbons stoking machines, and Drake's combined charging and discharging machines. There are also West's charging machines converted to the De Brouwer projector chargers. The general design of each of the types of machines mentioned is well known. Some of the points suggested in their use by experience at Beckton may, however, be of interest.

In No. 7 retort-house two Drake's combined projector charging machines have been installed. These are powerful and strongly-built machines, and, with 12-hour charges, one of them easily deals with the 270 retorts in the house; the second machine being held in reserve. A charge of 18 cwt. is normally put into these retorts; but the machine is capable of completely filling them if desired. The time taken in discharging and charging is 1½ minutes. In a larger retort-house, where two other Drakes' machines have been installed, the machines work together; one pushing and the other charging—the time being approximately halved. For successful charging with these machines, it is essential that the coal should flow evenly into the rotors or projectors. Therefore the coal-breaking plant must be thoroughly efficient, and precautions taken to exclude foreign matter, such as pieces of wood or iron. The comparatively large amount of smoke and dust caused by a projector machine when charging is of no consequence in an isolated works, but may be a serious objection in a works closely surrounded by other property.

Arrol-Foulis machines are installed in three of the houses containing old three-tier settings which have now become obsolete, so that the houses are only used for peak loads in the winter. The machines, too, are of old type and slow and expensive to work both in labour for operating and in wear and tear. Experience elsewhere with more up-to-date machines of the same make, however, has proved quite satisfactory.

West's scoop machines in three houses have recently been converted to the De Brouwer type of projector charger, and have proved so successful that the conversion of the machines in the remaining "West" houses is in progress. The machines continue to be driven by compressed air, and the original separate discharging machines have been retained. Only one of the charging machines in each house has been converted, and this easily deals with 300 retorts per shift of 8 hours. The reasons for the conversion were as follows:

(1) To increase the weight per charge so as nearly to fill the retorts, with the object of improving the tar and reducing the naphthalene content in the gas.

(2) To reduce labour operating costs.

(3) To increase the carbonizing capacity of the houses without increasing the number of machine operations, and with minimum capital expenditure.

(4) To reduce wear and tear.

The scheme was not novel—in fact, before a decision was made, favourable observation had been made of such plant in operation at the works of another Company. The results obtained have fully justified the alteration. The weight per charge has been increased by over 20 p.ct., stopped pipes reduced to a minimum, and throughput increased with fewer charging operations. Labour has been reduced by one machine driver per shift. As the charger and discharger are placed on the same side of the bench, and a coke-stop is left in the retort, it is not necessary to employ a stopper-plate man. Wear and tear is found to be much lighter than with the scoop machines; and in this connection it may be mentioned that one D.B. belt (with the coal path re-rubbered once) has projected no less than 90,000 tons of coal.

The well-known Fiddes-Aldridge simultaneous discharging and charging machines continue to give excellent service. Two of them have for many years dealt with the largest house at Beckton, which contains 440 retorts. The weight per charge of a 20-ft. retort is normally 12 cwt., and the duration 10 hours. Where heavy charging is insisted on, this machine is at a disadvantage, the charge in retorts

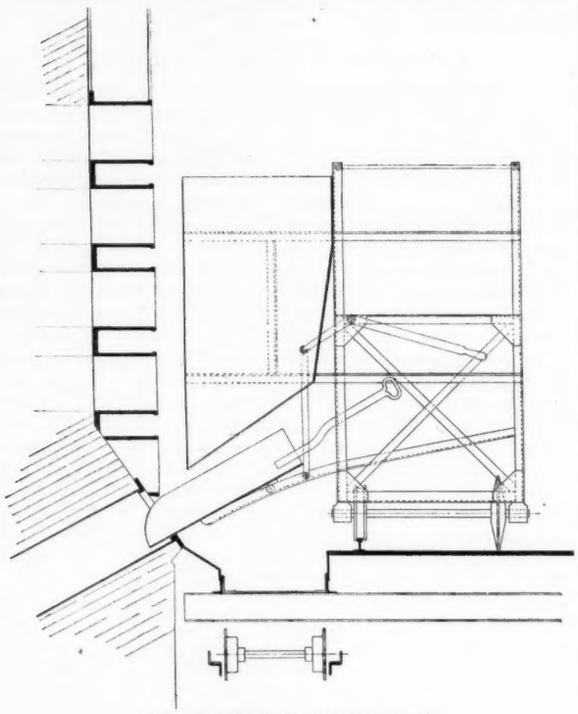


Fig. 6.—Old Type of "Coke-Bus."

of the same size being about 20 p.ct. less than with projector machines. The best charges are obtained with a newer pattern of chain fitted with a stop-plate device, which follows the tail of the charge and remains in position until the last length of chain is withdrawn, thereby reducing to a minimum the dragging-back action of the chain and push-plate. Maximum charges with this machine entail the strictest supervision of the backing-up of the charge, if waste is to be avoided. These machines complete the simultaneous charge and discharge in about 45 seconds.

The work demanded of any machines in dealing with large retort-houses as at Beckton (containing from 270 to 440 through retorts per house) constitutes a severe test of their capabilities, and demonstrates the importance of selecting a machine suitable in speed and capacity to the size of the carbonizing unit, if economy in working is to be attained. A trial was made with a Guest-Gibbons charging machine some little time ago. The machine showed itself capable of laying charges which left nothing to be desired; but owing to its limitations in speed, it was found quite unsuited to deal with so large a unit. It is now in operation at another works in a smaller retort-house, and the writer is given to understand that it is doing its work in a very satisfactory manner—which, from his experience, he should fully expect. A long trial was made with a Fiddes-Aldridge machine fitted with a fast-running conveyor. This machine did all that was expected of it in depositing a full, even charge; but it was unable to stand-up to the work required in a house of 300 retorts.

An auxiliary to the stoking machinery, which has recently become standard at Beckton, is the furnace-filling chute, or "Coke-Bus," of new design (fig. 6a). This chute was introduced to work in conjunction with the deepened producers, and to obviate the arduous and costly labour of poking back the fuel. The chute is suspended from bogies provided with roller bearings, and the body is constructed of plates curved to direct the fuel into the producer with maximum velocity. The advantage of curved plates will readily be seen. The apparatus is provided with a hand-wheel and chain drive, and is easily operated by one man.

Coal Plant.

At Beckton the coal is discharged from the colliers into hopper-bottom wagons holding about five tons, and is run from the pier to the retort-houses on a high-level railway.

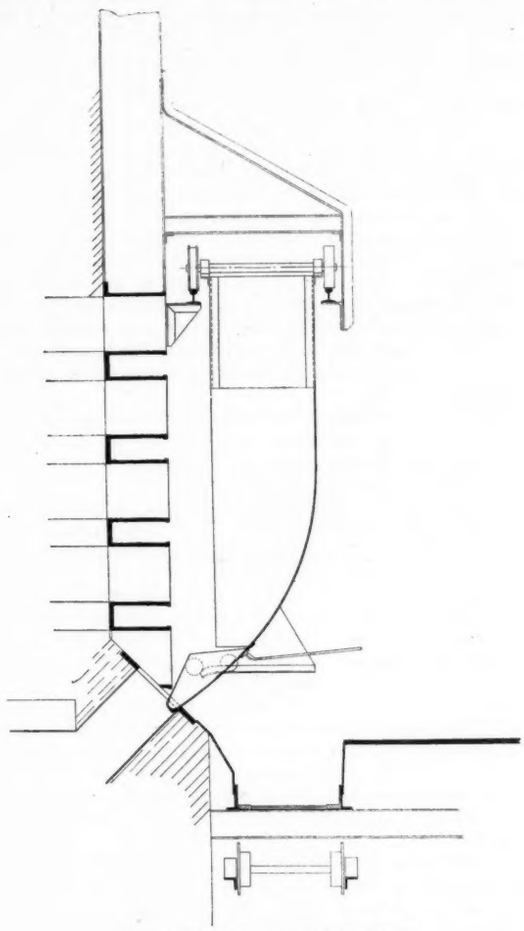


Fig. 6a.—New Type of "Coke-Bus."

Owing to the lay-out of the works, it is not possible to leave the wagons to be discharged one at a time directly into a receiving hopper over the breaker, as is generally the case. The whole train must be emptied in as little time as possible, in order to clear the line to other houses. Consequently, coal handling at Beckton forms a very considerable item in retort-house costs. The average cost was upwards of 6d. per ton, the greater part of which was due to the employment of coal trimmers. To overcome this difficulty in No. 7 house, it was decided to instal under the high-level railway a receiving hopper capable of holding 700 tons. The coal is delivered to the breaker from this hopper by means of a drag-link conveyor having a capacity of 120 tons per hour.

Capacity of Plant and Duplication.—To obtain a low cost per ton for coal handling, the plant should be of such a capacity as to enable the work to be completed within one 8-hour shift. The author has found it a good rule to divide the carbonizing capacity of a retort-house by five—that is

to say, arrange the plant so that it would do its work in five hours if fully loaded; the remaining three hours being taken up by occasional stoppages, oiling up, and meal times.

The very high cost of plant in these days makes it necessary to consider carefully the question of duplicate plant. Breakdowns will occur, no matter how well a plant is designed; and it is very comforting to know that if a breakdown does occur, there is another unit in reserve. Much, of course, depends upon the circumstances in which the particular installation is run; but it may be taken for granted that in most cases it is advisable to have a reserve of some kind. With the exception of the feeding conveyor, which can be bye-passed, the No. 7 coal-plant is divided into two complete units, each having a capacity of 60 tons

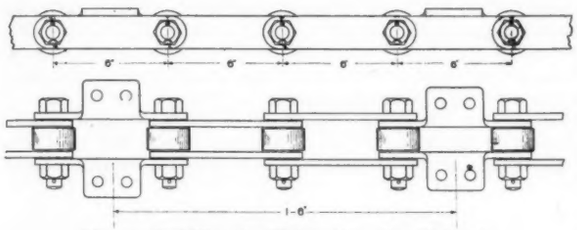


Fig. 7.—Coal Elevator Chain. No. 7 Retort-House.

per hour. Both sets of breakers and elevators are run at the same time to give the required capacity. A breakdown would mean extra time being worked; but this would probably be found much cheaper than paying the capital costs necessary for providing two full-capacity units.

Details of Coal Plant.—After considerable experience in designing and working this class of plant, the writer has no hesitation in stating that in his opinion the single-roll breaker of the Jeffrey type is the most suitable for use in gas-works. It will deal with all classes of coal or cannel, and can be adjusted so that the size of coal may be varied from almost dust up to 2-in. cubes. It may be of interest to note that during the latter part of the war, owing to the breakdown of other plant, it became necessary to use a standard 24-in. Jeffrey breaker for breaking-up old firebricks for concrete making; and so well did it carry out this very severe task that it is still being used for the purpose.

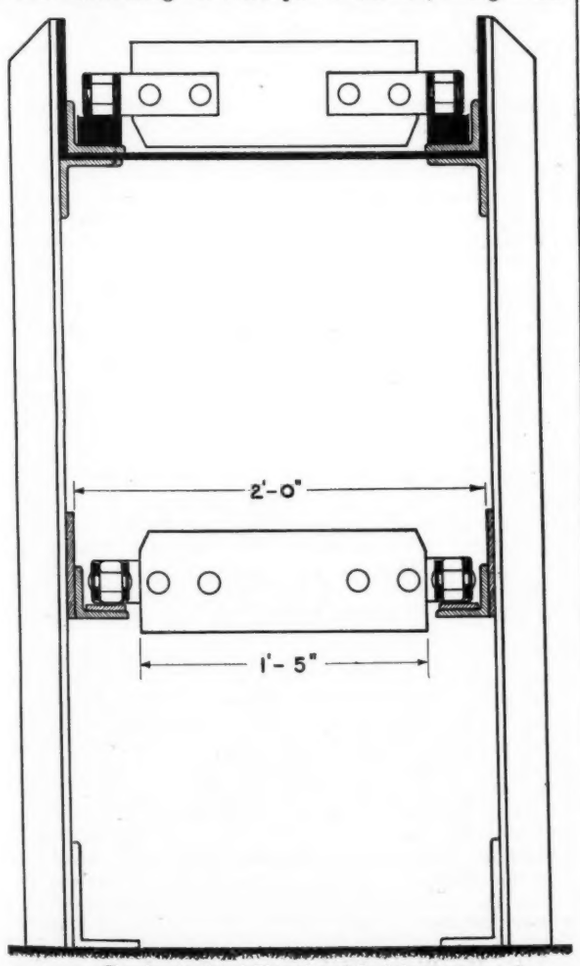


Fig. 8.—Sectional Elevation of Coal Conveyor.

While malleable cast chains are very suitable for many types of elevator, the author is strongly of opinion that the best chain for coal elevators (especially those installed in retort-houses) is the mild-steel roller chain, having side links not less than $\frac{5}{16}$ in. thick. These chains will stand shock, and, in spite of the small wearing surface of the pins, have a considerable life. Fig. 7 gives details of the chain now adopted as a standard at Beckton.

The whole of the gearing in No. 7 house is of cast steel. The cost of cast-steel gearing when compared with cast-iron may be considered high; but when taken on the cost of the installation as a whole, the extra is trivial compared with the security given.

Fig. 8 shows the type of coal-conveyor installed in No. 7 house. This departure from the usual push-plate type was decided upon in order to save the time spent in lubrication and on wear and tear. It is anticipated that the chain will have a considerable life, and there should be little risk of breakdown.

The labour charges in connection with the operating of the coal-plant in No. 7 house work out at one-third of a penny per ton. This will be regarded as a satisfactory figure

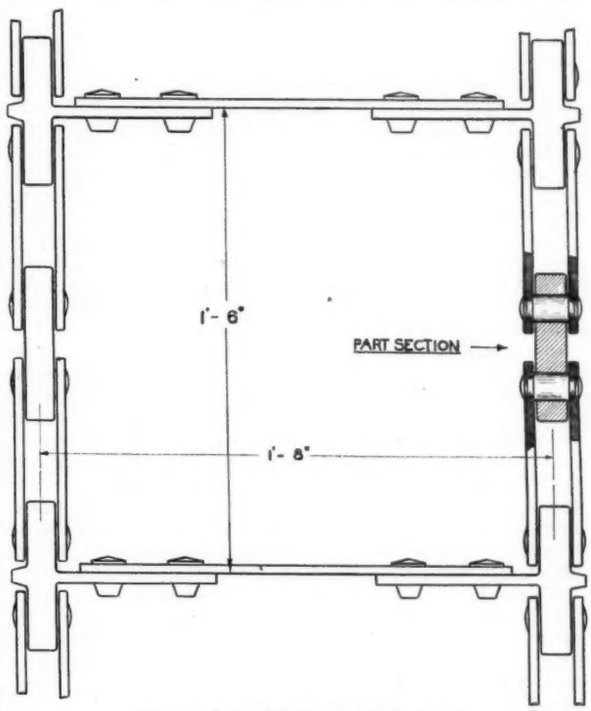


Fig. 8a.—Plan of Chain of Coal Conveyor.

—especially when the additional feeder conveyor is considered. The whole of the work, including the lubrication, is done by one man.

The overhead coal-hoppers have a capacity of 1000 tons, or two days' supply. This, with the 700 tons held by the receiving hopper, might be thought too generous for a 540-ton per day retort-house; but the extra storage is rendered necessary by the general coaling arrangements obtaining at Beckton.

Coke Plant.

One of the most difficult problems with which a gas engineer is faced, is the handling of coke. Apart from its abrasive character, and the resulting high wear-and-tear charges for the up-keep of plant, it is very friable; and unless carefully handled, the percentage of breeze grows alarmingly. Again, with most types of carbonizing plant, the question of quenching is one which requires considerable attention. The author's experience is that it is difficult to find the happy medium where coke quenching is concerned—and he does not think he is alone in this trouble. If the coke be dry, troublesome fires occur in the storage hoppers or heaps; and no sooner are quenching arrangements altered to overcome this difficulty than it becomes

apparent that the percentage of moisture in the coke is on the high side.

Hot Coke Conveyors and Telphers.—Where it is possible to arrange the plant so that the coke can be carried to the end of the retort-house and delivered to a hopper by means of one conveyor only, there would be no difficulty in deciding to use the De Brouwer type; but where it is necessary to introduce cross conveyors (as is the case at Beckton), the writer is inclined to look further afield. The carrier type of conveyor is, in his opinion, only suitable for dealing with cold coke; even then it is pointed out that the cost of upkeep is excessive.

Except for small plants, where the work can be easily dealt with, a telpher plant is undoubtedly too slow; and the difficulties raised by bulk quenching are not easily overcome, even in the case of such plants.

Transporting and Quenching Benches.—After inspecting several plants, the author came to the conclusion that the type designed by Messrs. Drake, of Halifax, would be the most suitable for the requirements at Beckton. In the No. 7 plant coke is discharged from the retort into the transporter skip, and is then elevated and tipped upon the quenching bench. The transporter is operated by one man, and works at an average rate of 1½ minutes per retort. A 10-H.P. motor is fitted for hoisting, and a 7-H.P. motor for travelling. No water is applied to the coke until it reaches the quenching bench, and it is, perhaps, due to this fact that the skips keep their shape and give promise of a long life, estimated to reach from two to three years.

The quenching bench, which is set at an angle of 40°, is constructed of ferro-concrete faced with firebrick, and extends the full length of the house. It is fitted with sliding doors through which the coke is fed into telpher skips. For the quenching, two centrifugal pumps of a total capacity of 10,000 gallons per hour at a pressure of 80 lbs. per sq. in. have been installed, and the water is directed on to the coke by means of ball-socketed nozzles mounted on a platform supported on the telpher trestles. It may be mentioned that the colour of the quenched coke is somewhat disappointing. It was fully expected that this would be similar in appearance to hand-quenched coke—*i.e.*, silvery grey. It has, however, rather a dark appearance—even darker than coke quenched in a conveyor. During a recent visit to the United States, the writer noticed that where oven coke was quenched in a manner similar to the method adopted in No. 7 plant, the colour was much the same.

The excess water from the quenching bench is filtered before running into the channel, through which it returns to the pit to be used again. The design of filter may be of interest. On a ledge about 9 in. from the top of the channel, wooden grids are fixed, covered with a layer of small coke about 6 in. deep, and then made-up to ground level with fine breeze. This filter has been in operation for a period of about 7 months, and has not required any attention up to the present. The water returned to the pit is quite free from grit. The wear and tear of the impeller blades of the pumps is thereby reduced to a minimum. From the quenching bench the coke is dropped through the sliding doors into telpher skips of two tons' capacity, and is thereby conveyed to the storage hoppers. These are constructed of reinforced concrete, and have a capacity of 500 tons, or a 2 days' make of coke. The sloping surface of the hopper bottoms is lined with 2-in. Staffordshire blue tiles.

Coke Screening.—Coke screening is a problem for which a really satisfactory solution has yet to be found. The writer has tried most designs of screens fixed in all manner of ways and places, but has been driven to the conclusion that a clean, dust-free coke can only be obtained when it is screened as loaded into the consumers' wagons. Each of the ten hopper doors is fitted with a balanced shaking screen of the "cascade" type. This arrangement is more costly to instal in the first place than the ordinary type of plant; but as each screen only deals with one-tenth of the total coke made, the life should be proportionately longer, and the wear-and-tear costs no greater per ton of coke handled than with other types.

The labour costs for operating the complete coke-plant of this type work out at 4·5d. per ton of coal carbonized, and from this point of view compare unfavourably with the existing plants, which cost 1·5d. per ton of coal. The difference is more than balanced by the maintenance costs, which promise to be very low for our No. 7 plant; moreover, there is much less breeze made. An average of several tests, in which many hundred tons were treated, gives the following figures:

	Percentage.
Large coke	81·1
Small coke, 1 in. to 2 in.	11·8
Breeze below 1 in.	7·1
Total coke treated	100·0

This result compares very favourably with that from any type of coke-conveying plant.

American Practice and Belt Conveying.—During his visit to the States, the author was much impressed by the methods adopted there for handling coke. The rubber belt conveyor is being generally used for handling cold coke; and the opinion of most of the users was that the life of a rubber belt used for this purpose should average about one million tons. The belt seen in use at the Clairton coke-oven plant at Pittsburg had handled 800,000 tons, and was still in excellent condition. Judging from its appearance it should more than reach the million. He was also much interested in a new type of coke-screen known there as the "Grizzley" screen, consisting of a number of chilled cast-iron discs mounted on parallel shafts which revolve in the same direction (see fig. 9). This screen gives an excellent separation, as the coke rolls over during its passage through the screen the wear and tear costs should not be excessive.

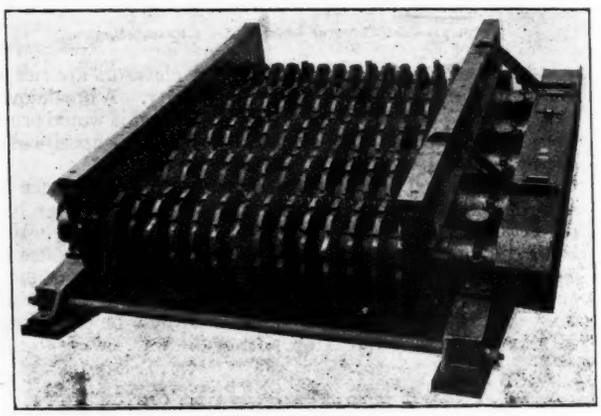


Fig. 9.—Grizzley.

While dealing with the subject of coke handling, he might mention that he has successfully used a rubber belt conveyor for handling wet breeze. The chief objection to the use of a belt for this purpose is that the wet grit which clings to the surface rapidly wears-out the return idler rollers. A brush was fixed in the first place to clean the belt; but this after a day or so became solid. It was found, however, that the belt could be entirely freed from grit by the use of water jets. These should be about ⅛ in. diameter, and spaced about 4 in. pitch, and the belt should be wide enough to render side guides unnecessary. The maintenance cost for a belt of this type is considerably less than for a tray or other type of carrying conveyor.

Purifying Plant.

Ferro-Concrete.—The purification area at Beckton was very limited, and, in view of the desirability of separating the make from each retort-house, it was decided to increase the capacity by two additional sets capable of dealing with a total of 8 millions per day. At the time the matter was being considered, the high cost and the difficulty of obtaining delivery of cast-iron boxes, left no alternative but to erect in ferro-concrete.

Two sets of five, 45 ft. by 30 ft., overhead vessels have been erected, fitted with luteless lids and Milbourne duplex valves. On account of the shortage of ground space, an oxide storage floor has been built over the boxes. The latter were rendered over on the inside with two coats of "ironite" and proved water-tight on testing; but some leakage takes place when an air-pressure test of 44 in. is applied. This is receiving attention. Most of this leakage is in the decking, which did not benefit (as did the sides and bottoms) by the hydrating of the cement during the water test. After some experimenting, the author is led to believe that the best means for making concrete purifiers gas-tight would be to render the inner surfaces with super-cement to a thickness of ⅜ in.

Oxide Handling.—With the erection of new purifiers,

various means were considered for handling the purifying material, and care was taken to avoid an error so often made in connection with plant of this kind. The difficulty is to find a plant which, when required, will handle the material at the necessary speed without incurring capital charges outweighing the advantages. Take, for instance, a set of purifiers consisting of four boxes, each holding say 150 tons of oxide, and allow for changing the material once every three months. This would give a total of 2400 tons to be double-handled in 12 months. The labour costs in charging and discharging only would be about 2s. per ton, giving a total of £240 per annum, a sum which does not provide any great scope for saving. A plant for handling the material mechanically would cost roughly £3000. Without considering maintenance charges, the interest on the capital and the sinking fund would amount to more than this figure. It was necessary, therefore, to instal a plant which would have other advantages than handling the material; and, as at that particular time a scheme for discharging the Company's colliers by means of a suction plant was being considered, it occurred to the writer that plant of this type would not only handle the material, but would at the same time deliver it to the storage floor in such a condition that it could be used again almost immediately. As a matter of fact, material has been returned to the boxes within 24 hours with satisfactory results. It was then decided to instal a handling plant on the pneumatic system, designed by Messrs. Henry Simon, Ltd., of Manchester. The method of operation is simple. The spent material is tipped from trucks into a hopper feeding a disintegrator, from which it passes to a rotary seal (see fig. 10) and thence into steel pipes, through which it is carried by a stream of air under pressure either to the storage floor or into wagons to be conveyed for use on other purifying sets.

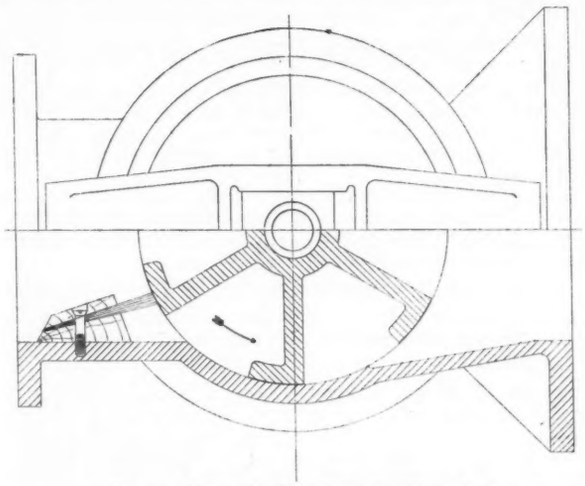


Fig. 10.—Rotary Seal for Oxide Handling Plant.

This plant is capable of dealing with from 110 to 150 tons per working day, according to the percentage of moisture in the material, and can be erected with a capital outlay, including foundations, of about £2500. Assuming that the plant is kept fully employed (as it is anticipated it will be at Beckton), it is estimated that a saving of 2s. 6d. per ton in the preparing and the handling of the material will be obtained.

American Practice.—Dealing with the subject of oxide-handling plant reminds the writer of an incident during his visit to a gas-works in the States, and which struck him as typical of the methods of the American engineer. On looking round the purifiers, he noticed a rather elaborate gravity bucket plant which had been erected to feed a set of overhead boxes, and was much surprised to find on reaching the other side of the boxes that they were being filled by means of a portable rubber-belt conveyor. He was informed that the portable conveyor was much cheaper and more convenient to work, and that the gravity bucket conveyor had been discarded.

Carburetted Water-Gas Plant and Other Installations.

The original carburetted water-gas plant was laid down in 1890. It is of interest to note that this, the first oil-gas plant in England, was installed by our late Chief Engineer, Mr. Thomas Goulden. The growth of the demand gradually outstripped the capacity of this plant; and in 1911 it was decided to replace it by a thoroughly up-to-date installation which would consist eventually of nine twin generators of a nominal capacity of 3 million c. ft. per set per day. This figure, however, has been exceeded, and the complete plant is capable of producing 30 million c. ft. of gas per day. The first section with five twin generators was built in 1911; in 1919 two more were added; and in 1921 the original scheme was completed by the addition of two twin generator blue water-gas sets, each with waste-heat boiler attached. The waste-heat boilers are each capable of providing sufficient steam to supply the generators to which they are attached. These sets have only recently been taken over from the contractors, and it is too early to give figures concerning the working. No difficulty, however, has up to the present been experienced in operating them.

A special feature of the Beckton water-gas plant is that the generators are supported upon columns, and are high enough to permit railway wagons to be run beneath them for receiving the ashes and clinker direct from the generators. The plant is operated by hydraulic power; and the blast for the generating plant is provided by five Rateau type fans, each driven by a steam turbine of 110 H.P. One of the blue-gas sets is being fitted with an automatic electric operator which, it is hoped, will be at work at an early date.

Boilers.

The most important addition to the steam-raising plant has been the installation of a battery of four Babcock and Wilcox water-tube boilers, each having an evaporative capacity, when burning coke dust, of 14,500 lbs. of steam per hour. They are fitted with chain-grate stokers and balanced draught fans. The fuel used is fine breeze from half-inch to dust; and it was principally with a view to finding a means of utilizing these screenings that the chain-grate stoker was adopted. This type of grate has been found a very effective check on the breeze screening plant, as trouble is at once experienced with the combustion if breeze of larger size is delivered to the grates.

Balanced draught is necessary for furnaces burning this class of fuel; and this is obtained by means of an exhausting fan situated at the base of the chimney shaft, and a pressure fan for delivering air to the under side of the grates. With this arrangement there is neither an excess of pull nor pressure over the fuel-bed, and the tendency of the finer particles of the fuel to lift is obviated to a great extent.

The fuel and the ashes are handled by means of a telpher. The operating costs are low, as the plant is operated by one stoker and one ash attendant per shift; and one telpher driver can handle the whole of the fuel and ashes in eight hours.

Turbo Blowers and Condensing Plant.

The most notable addition to the gas pumping plant is at the No. 1 distributing station, which is in effect the oldest high-pressure distributing plant in the world. Here, by means of rotary exhausters, the gas is delivered into two 48 in. truck mains at pressures up to 50 in. The large extensions to the productive capacity made the existing plant too small. It was decided, therefore, to remove two of the older sets, and instal in their place two sets of Reavell's direct-coupled turbo blowers, making provision for the addition of a further two sets at a later date. Each of these blowers is capable of delivering 1½ million c.ft. of gas per hour against 80 in. head of water. The blowers are of the two-stage double-ended type, and are so arranged that the gas is drawn from the ends and delivered into the centre. By this arrangement, the axial forces of the shaft are cancelled, and at the same time the sealing of the machine is much simpler, as it is only necessary to provide a seal against the holder pressure.

A notable feature of these machines is the provision of a special form of diffuser apparatus, consisting of a number of stationary guide blades, which receive the gas immediately it leaves the impeller, and conduct it to the next impeller with the least possible eddying action. These blades (the makers claim) produce a steep characteristic at the point at which the machine is designed to work, and consequently the pressure will rise and fall a considerable amount for a very small change in volume, so producing exactly the conditions required for stable working in parallel with the

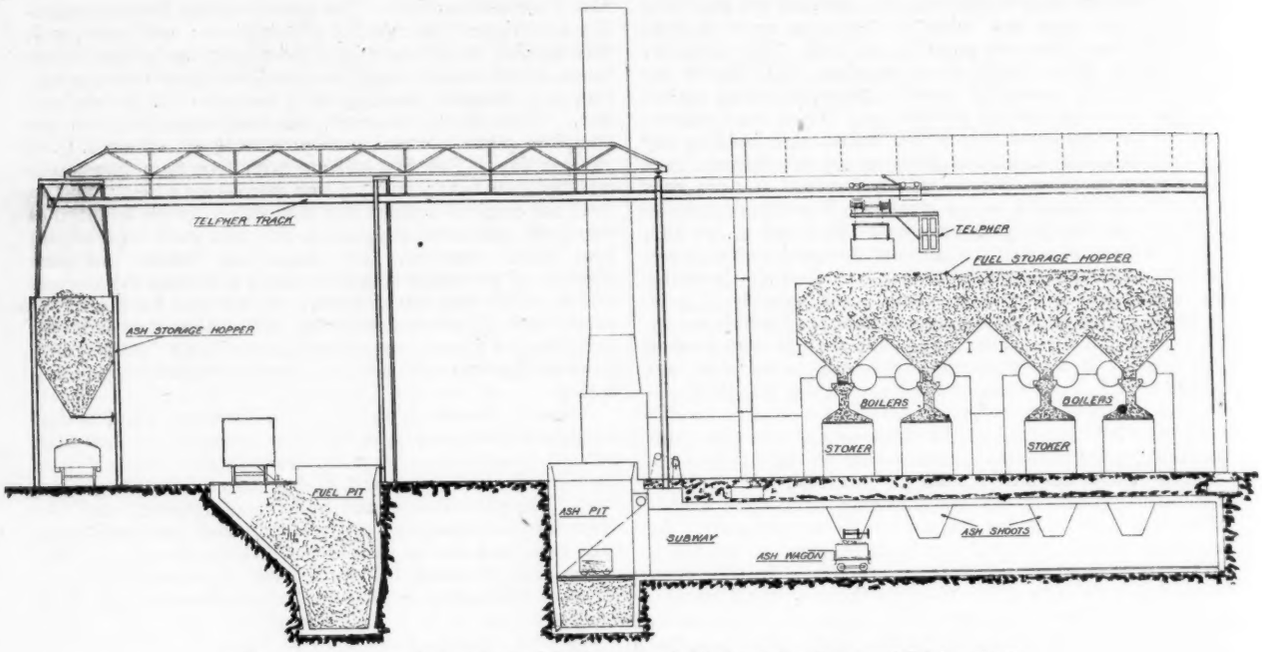


Fig. 11.—Diagrammatic Longitudinal Section through Oil-Gas Boiler House and Telpher Track.

other, or (what is equally important) for running in parallel with existing rotary exhausters. Considerable doubts have been expressed as to the ability of the plant to fill these conditions; but in actual practice the machines parallel-up, and can be put into or out of operation without difficulty and without any variation in the pressure.

The condensing plant is of the surface type, maintaining a vacuum of 27½ in. The air pump and water circulating pump are both direct-driven by an auxiliary steam turbine, exhausting into the main condenser; and a cooling tower has been provided for dealing with the circulating water. Steam is supplied to the turbines at a pressure of 60 lbs. per sq. in., and is not superheated.

The only trouble experienced with the plant was the erosion of the blades of the auxiliary turbines, due to the steam being wet. It is hoped to overcome this fault by fitting the rotor with stainless steel blades in place of the existing ones (which are of gunmetal), and by the introduction of steam separators.

The saving in floor space, by the adoption of this type of plant, is a very important feature—especially at Beckton, where foundations have to be carried down to at least 25 ft. below ground level. The plant, which will have, when completed, a capacity of 6 million c.ft. per hour, will occupy 1820 sq. ft. as against 7800 sq. ft. required by the existing plant, the capacity of which is 4½ million c.ft. per hour.

New Engineering Workshops.

As the works have gradually changed from hand-worked to mechanically-operated carbonizing plant, together with a general increase of mechanical appliances, the maintenance staff has grown proportionately. The original buildings have been extended, and additional shops built from time to time to relieve the position; but the volume of work had grown to such an extent that it was evident that if it was to be done at a reasonable cost, proper accommodation would have to be provided. It was then decided to build on a new site a shop large enough to house the whole of the engineering and constructional departments.

The new building, which is of reinforced concrete panelled with glass, is 360 ft. long by 120 ft. wide. The shop itself is divided into four 30-ft. bays, two of which are equipped with 5-ton electric cranes, the other two being provided with 2-ton hand cranes. At one end of the building of which it forms a part, and overlooking the shop, is a three-story block of offices. In these offices accommodation is provided for the officials and staff of the mechanical and constructional departments, who control some 1530 men. At the other end of the building is a similar three-story block comprising the stores, mess-rooms, and lavatories. It may be difficult to those not acquainted with Beckton to understand why a workshop of such size is necessary in a gas-works; but when it is mentioned that besides the ordinary gas-making plant there are over 1500 broad-gauge railway wagons, 40 locos, 48 steam and hydraulic cranes, and other plant in like proportions, the reason will be apparent.

Water Supply and Filtration Plant.

The question of water supply may, perhaps, not be of general interest to the gas engineer; but at Beckton it has for years constituted the source of many troubles. Generally speaking the water used on the works is divided into two classes:

1. The clean water service amounting to approximately 1 million gallons per day, which is obtained from the Metropolitan Water Board.
2. The "dirty" water service (about 3 million gallons per day), which is, with the exception of a limited supply obtained from the bore holes, pumped from the river.

As the river water contains a large quantity of suspended matter, further efforts were made to find water on the works; and a pit was sunk on the foreshore to a depth of 45 ft.; but in spite of the fact that it was within 20 ft. of the river wall, the supply at any state of the tide did not amount to more than 10,000 gallons per hour. It was then decided to instal a filtration plant; and a scheme put forward by Messrs. The United Water Softeners Ltd., was accepted. The water to be treated and filtered is raised from the river by centrifugal pumps driven by vertical spindle electric motors. These are arranged under No. 2 pier. The pumps are placed at about half-tide level, thus being entirely submerged at high tide and having a maximum suction lift of approximately 14 feet at low tide. The filtration plant is housed in a reinforced concrete building. It comprises eight filters with adjoining basins for coagulation and sedimentation, together with a tower for the storage of water for washing the filter beds, and also a filtered-water reservoir from which the water is pumped into the works' mains at a pressure of 80 lbs. per sq. in. The plant is intended to take a maximum of 4 million gallons per day of crude river water, and to clarify it sufficiently for use for industrial purposes on the works.

The sedimentation of the suspended and siliceous matter is assisted by the addition of a very small proportion of lime, which has the effect of coagulating the floating particles and hence causing them to fall more rapidly in the settling tanks. The finer impurities are then removed by sand filters. The settling tanks are arranged in two independent halves, so that each can be worked or cleaned separately, as desired. The filters are cleansed by agitating the filtering medium with air at a pressure of about 4 lbs. per sq. in. A reverse current of clean water is then applied to the

under side of the filter-bed, and the impurities deposited on the sand are floated over into the waste collecting troughs.

New water distributing mains are being laid throughout the works, and will enable the full advantage of the plant to be obtained, which will undoubtedly eliminate the great difficulties attendant upon the use of unfiltered river water.

CONCLUSION.

Since the end of 1918 the demand for gas has increased to such an extent that at times pressures were only maintained with the greatest of difficulty. The heaviest consumption for one week in 1918 was 810 millions; in 1919, 875 millions; and in 1920, 973 millions. The consumption during the summer months also showed a considerable improvement, and it was due to this increased demand that the extensions and the reconstruction work described in the paper had to be undertaken, at a time when plant of any description was very costly. During this period the gas-making capacity of the works has been increased from 70 to 87 million c.ft. of gas per day; and when the plant which is now being erected in No. 6 retort-house is completed, the total capacity will be 93 millions.

In order to make room for the extensions, plant (more or less obsolete) amounting to 9 millions per day has been demolished, so that the total additional plant is equal to 32 millions.

Owing to the difficult times which have been experienced during the last three years, serious delays have occurred in the completion of several of the contracts; and the works are only now beginning to benefit fully by their installation. The improvements made to the carbonizing plant have reduced the number of men employed in the retort-house by 36 p.ct. This figure was arrived at by comparing the number of men employed during a week at the end of 1918 with a week in the early part of the present year (1922), the quantity of coal gas being the same in each case. A comparison of the labour costs per ton is misleading owing to the many changes in the wages paid during the period under review. Besides this saving, the yield per ton of coal has been increased from 64 to 70 therms.

Owing to the heavy demand for gas and the non-completion of new purifiers, it was not possible, until quite recently, to isolate No. 7 retort-house for a period sufficiently long to enable reliable gas-making figures to be obtained. However, a week's test recently completed shows a yield of over 72 therms per ton. This result, together with the improved coke returns and the low labour charges, would seem to justify the decision to instal a similar plant in No. 6 house.

The PRESIDENT: You have heard a description of some work which has been undertaken in the last few years at the Beckton station, under Mr. Leech's charge; and from what he has said, you will see that this work has been fairly extensive, and that a heavy responsibility rests upon Mr. Leech himself. This paper, I am sure, will appeal to all engineers here. It is work you have all had to do. It is work you are all busy with to-day—reconstruction of plant—and I have no doubt there are a great many of you very anxious indeed to criticize what has been done at Beckton. I will not stand between you and the reader of the paper, but will let you get at him straight away.

Discussion.

Mr. P. S. HOYTE (Plymouth): The paper to which we have just listened has a double, if not a treble, interest to us all to-day. In the first place, the President is the Chief Engineer of the Company, and is responsible for the Beckton works. Mr. Leech is known to us as a thoroughly practical man; and this, if I may describe it so, is a thoroughly practical paper, and a fitting supplement to that which we had from another London Company last year by Mr. Gill. The Beckton works have, I think, since the boyhood of all of us, been a sort of Mecca; and I am sure many of us here must have felt a slight thrill when that first photograph was thrown on the screen representing the Beckton works, with that wonderful litter of holders, each one exactly like the other. When they wanted increased capacity, they put another one down to exactly the same plan and specification as the previous ones. This paper is trebly interesting because we are all extremely interested at the moment in extensions of plant. It is a question of "are we going to put down verticals or re-model our horizontals?" I had the privilege of going over the Beckton works a few months ago; and I am greatly looking forward to the visit we shall be paying on Friday, to see the progress that has been made. I was greatly fascinated with the lay-out of the latest retort-house, and particularly as to the reason why there is a persistence, at Beckton at any rate, in the horizontal retort. It is most certainly a retort into which you can put any class of coal. The Gas Light and Coke Company have a very large works; they can afford to experiment in small corners on the things that some of us dream about occasionally—complete gasification, and bumping our heads against the stars and getting 90 p.ct. of the value of the coal. We may hear something about that later; but I wish that Mr. Leech could have expatiated at some length on the Congdon standpipe, which they have tried at Beckton. There is not one of us who would not like to get rid of these horrid ascension pipes; and if anything can be done with the Congdon pipes—wonderful things have been done in the States with that particular system—we shall be very glad. No doubt the officials of the Company will have further experiences to relate when we go down to Beckton on Friday. I am sure the way they deal with the coke in this retort-house will appeal to many of us. Those of us who have discarded the coke-conveyor system, largely on account of its high cost of upkeep, and the enormous percentage of coke which it turns into breeze immediately on leaving the retort, will be very keen on seeing the system at Beckton. They seem to have surmounted the difficulty of that brutal baptism, which is the custom of most, of total immersion by treating the coke on a bank and hosing it down. We should also have been interested to hear what Mr. Leech estimates, with present prices, would be the cost of cast-iron purifiers. I am particularly interested in this question of concrete purifiers as compared with the usual type of cast iron.

Mr. G. M. GILL (London): I, like Mr. Hoyte, have much appreciated Mr. Leech's paper. As has been said, most of us are carrying out schemes of reconstruction; and many of the points raised by the author will be very suggestive and instructive to other members. I should like to ask Mr. Leech a few questions arising out of the paper. Early on, he speaks of 75 therms in connection with intermittent verticals. I take it that is with steaming. With regard to the 24 in. by 18 in. Ω-shaped retorts at Beckton, I see they hoped to carbonize 20 cwt. in 12 hours. I take it from the paper that they were not able to do that. He states that he found it was necessary to work with a combustion chamber temperature of 1400° C. in order to do what he wanted. There is no material I know of except silica which would stand that. We have worked some of ours at that temperature with siliceous material; but I do not think it would hold out very long. Of course, in America, where they are using silica material for retorts and retort walls almost generally in up-to-date works, they work at much higher temperatures—up to 1450° C.; and it is a question whether that is not going to be the best practice in future for British engineers. I should like to know whether in connection with the 23 ft. retorts, any special difficulties in repairing the centres of such long retorts are experienced. It seems to me that there is some difficulty in having to repair a hole in even a 20 ft. retort. Mr. Leech says that he is getting 25 p.ct. more output from his plant. What is his make per retort in therms? I have been looking into figures, and it always seems to me that the make per retort is of more importance than the make per ton from the point of view of cost of making gas. In fact, it appears to me to be a good deal more important. I notice the author speaks of reverting to two ascension pipes to a retort. I agree that this is much better practice. Then he refers to dry mains. I do not know whether he means that there is no liquor at all in the main. We work with what I suppose he means by dry mains; but we call them unsealed, and there is liquor in these mains to within half-an-inch of the bottom of the dip pipes. This is rather necessary, so that what tar is formed is carried away by the liquor; and just the same amount of flushing takes place in these unsealed hydraulic mains as in those that are sealed. We have had no experience of a flare going down one pipe, while there is a pull on the pipe next to it. I should like to mention that we find the greatest advantage in dividing our retort-houses into units—preferably four settings of ten in each unit. Each unit has its own retort-house governor, and delivers its gas through the governor into a receiving main. In this way, if you have the retorts open in any particular unit, that is the only unit you need check. The others can be under their full amount of vacuum. There is certainly considerable gain by dividing into units in this manner. I notice Mr. Leech refers to West scoop machines. At the Old Kent Road, my Company have these machines, and find them excellent for putting-in heavy charges. That the charges look practically full there, will be borne out by those of you who have seen them. The West scoop machines are certainly light in wear and tear, and compare very well with the Arrol-Foulis in this respect.

I notice that the tiers of retorts, five rows, are not placed directly one over the other. Our practice is to place retorts directly over each other. We find in this way the retorts wear out together. You do not get the top two rows getting more of the heat by reason of projecting more than the others. There is considerable advantage in that. I should like to know whether, when the author speaks of an increase in the make per ton from 64 to 70 therms, he means in No. 7 house, which he has described, or whether it is for the old houses. I must congratulate Mr. Leech on giving us a most excellent paper, which will be of very great value to all of us.

Mr. W. M. CARR (Ormskirk): The information given in Mr. Leech's paper is of the greatest interest. I know it is difficult to embody in a paper of this magnitude detailed information, but, at the same time, I should like to ask Mr. Leech if he has a record over a number of years—and, after all, it is only in such large undertakings where records can be kept—as to the maintenance

costs of the various machines in use. I notice from the paper that the Fiddes-Aldridge machine is stated to be carrying out the work of charging and discharging in 45 seconds, as compared with 1½ minutes with the Drake machine. Of course, the charge is proportionately less—12 cwt. with one and 18 cwt. with the other—and I am assuming, although it is not stated, that the retorts in both cases are of the same dimensions. Therefore, the advantages in the matter of rate of carbonization would appear to be with the Drake machine in the new No. 7 house, with the charge of 18 cwt. with the twelve-hour period, as against the smaller charge of 12 cwt. with the ten-hour period. I would like to ask Mr. Leech if the retorts in both cases are the same size, because it would appear that with the machine under the heavier charge a greater output per retort can be obtained than with the Fiddes-Aldridge machine. I should be obliged if Mr. Leech could clear that point up in my mind, and probably it has occurred to several others. Another thing that appeals to me, although Mr. Leech did not mention it specifically, is that the paper once again draws our attention to capital expenditure. At Beckton, as Mr. Leech explained, they have land available—at least, I understood him to mean that. This being so, it left the Company very free to decide upon how much space they were going to take up with their carbonizing plant; but, other things being equal, it still appears to me that, given land to spare, the capital cost of an installation such as has been put down at Beckton must be very much less than the capital cost of the other intermittent verticals which were suggested as an alternative with greater efficiency. Mr. Gill has asked for information as to the yield of therms from the present No. 4 house, which will be very interesting, in comparison with the yield that was anticipated, of 75 therms per ton, from the intermittent verticals. I should like to thank Mr. Leech for the very valuable information he has given us in this paper.

Mr. C. DRU DRURY (Sunderland): While there is so much of interest in the paper, I simply wish to refer to two items. One is the fact that the author has adopted silica segmental retorts. In my house of 20 beds of retorts, I put in one of silica segmental retorts; and I found I was quite justified, from a refractory point of view, in doing so. But there are disadvantages. One is that carbon collects so quickly at the joints of the segments, and takes a long time to remove; also there is more cursing and swearing in pushing-out than in connection with any of the others in the retort-house. It does give considerably more trouble in the case of a pusher. The second item is the great benefit that the author had derived from deepening the producers. It was a remarkable result. No doubt the producers were shallow in the first instance. Only last week one of our assistants remarked how much better results he would get if I could see my way to deepen the producers in the retort-house. I pointed out the very heavy expense entailed by underpinning, and new foundations; but after what Mr. Leech has told us, I think I shall have to reconsider the matter.

Mr. R. E. GIBSON (Liverpool): I think Mr. Leech's paper is particularly valuable, because he gives the reasons for installing the various kinds of plant he has described. I want to say a word particularly with regard to the coke plant. He says: "One of the most difficult problems with which a gas engineer is faced is the handling of coke." This is a matter to which we have been giving very careful consideration recently; and it may be interesting to some of the members if I say that we have just put to work at Garston a machine which puts the coke out of the retort-house by means of the power of the pusher at the other side of the bench. The coke is pushed through a tube. The essential part of the machine is a tube of special construction, which is capable of being elevated to any height, and can be tilted at any angle, in either direction; and by means of this we are able to put the coke immediately outside the house on to a quenching bench, or into cooling chambers for the production of dry coke. The tube protects the men from the heat; there is no discomfort to the men by its use; practically no breakage of the coke; and very little production of breeze. Also, the machine is very useful in charging the producer. There is no necessity for a coke 'bus—the tube may be tilted in the opposite direction, and red-hot coke discharged into the furnace expeditiously. This machine has been working continuously since last March, and is, so far as we can see, quite satisfactory.

The PRESIDENT: How many tubes are there?

Mr. GIBSON: One tube only.

The PRESIDENT: What is the size of the retort-house?

Mr. GIBSON: It is working on a house of fourteen beds of ten retorts, five tiers high.

Mr. H. H. COLLETT (Danish Gas Company): I should like to join in congratulating Mr. Leech on his excellent paper. It is not the privilege of the majority of us to carry out reconstruction schemes on such a vast scale as they do at Beckton; but this communication will be particularly useful, when we have to carry out reconstruction schemes, as a paper of reference. I should like to ask Mr. Leech what the grate area of his producers is. This, I think, would be a very useful figure for us to have, and also I should like to know how often he fills his producers. Then, I should like to know whether he has found that the fluctuations in temperature in the retort-beds have been very much reduced since he deepened his furnaces. Mr. Leech mentioned in his paper the movement of the foundations; and I should like to confirm that. I had to examine a retort-house once which had side and gable walls. The foundations of the retort-beds were almost joined-up with the foundations of the walls. I had the flooring material cut out, and sand inserted, but it was quite obvious that it was simply due to the moving of the foundations. With regard to the coal elevator chain shown in fig. 7, this is a very useful chain indeed; but I take it that at Beckton the wear of the links comes directly upon the pins. There are no bushes in the pins; and I should like to ask Mr. Leech whether he has considered the point as to whether the bushes would not give a better wearing life, so that the pins would not be worn so much; the wear coming more directly on the bushes themselves. With regard to the coke-conveyor chain, that appears to be really the De Brouwer type; and I was wondering whether that chain works quite smoothly, and whether there are any means of lubrication. I once tried ordinary De Brouwer chains for moving cold coke; and the effect was that there was a great deal of jumping. Of course, the water, as a rule, acts as a lubricant, and certainly helps when you are conveying hot coke with a De Brouwer chain. Also, with regard to this chain, I should like to know of what material the wearing strips are made—that is, on the top part. Two black patches are shown; and I should like to know what that material is.

Mr. J. FISHER (Tottenham): Arising out of what the last speaker has said, and seeing that Mr. Leech has referred to American practice, I would rather like to ask him whether, in the case of a really new retort-house, where it would be open to the most suitable arrangement possible, he would not cut out coal elevators and make use of a rubber band. I understand this is adopted very freely in America, instead of using the elevator. In the second place, in dealing with the cold coke after it has been quenched on the inclined coke cooling skip, or coke wharf, as I understand they are called, would he prefer, if it were possible, in designing new work, to transport the coke on a rubber band rather than use a telpher or coke conveyor?

Mr. LEECH, replying to the discussion, said: With regard to the question by Mr. Hoyte on the Congdon pipes, our experience at Beckton has not been quite a happy one—probably due to the fact that the settings were not designed in the first instance to take Congdon pipes. I think one of the main points is to have the horizontal connecting pipes as short as possible between the top mouthpiece and the Congdon pipe itself. If they are long, you have almost as much trouble as with the ordinary ascension pipes. With a specially designed setting, I think the Congdon pipe might answer very well. With regard to the cost of ferro-concrete as against cast-iron boxes, even at the present time I think ferro-concrete boxes would be cheaper than cast iron; but, personally, I do not think it would make very much difference. I should go for cast-iron boxes if I had my say in the matter. With reference to Mr. Gill's question regarding the 75 therms with the intermittent vertical retorts, that, of course, is with steaming. The steam in that case was under about 10 lbs. pressure, not superheated. With regard to the heat in the retorts, 1400 C. is a high figure for a five-tier retort. The silica retort, I think, could be easily worked at 1400° C.; in fact, with the larger size retort on the ⌂ system, 1440° C. was the average temperature, and I used it in many cases with the Dessau retort. The Yorkshire retort (Morton's), in fact, we worked up to an average of 1440° C.; and they stood practically as well as the German retorts. I have not tried the silica retorts on the intermittent system. I have tried the Dessau retort, which is fairly high in silica; but Morton retorts do equally as well as the Stettiner. As to repairs to the 23 ft. retort, I think 23 ft. is about the limit. Of course, it is always difficult to carry out repairs to any length of retort. Retorts of 15 and 20 ft. are certainly somewhat difficult; and I do not think the extra 3 ft. makes very much difference. I would not go any further, at any rate. With regard to the make of therms per retort in existing houses, it is 95 therms. Mr. Gill asked about dry mains; I should have said unsealed pipes—that was what was intended. I have to deal with much the same conditions as Mr. Gill, and require about ¼ in. from the bottom of the pipes. It would, of course, be an advantage to have sections of four settings. I quite agree; but I think the anti-dip pipes would even have a greater advantage than that, because you are able to seal one retort at a time. The wear and tear on the West's scoop machines is rather excessive, and we are unable to get in three scoops, as I believe is practised at Mr. Gill's works. We have tried; but it is probably due to the shape of the retort. In the South Metropolitan Company the oval retort is standard. Ours are bell-shaped, and it would have meant bunching-up the charge. The increase from 64 to 70 therms is on the whole of the works, and not on No. 7 house. Mr. Carr asked for information as to the maintenance costs of the different machines. I am afraid I cannot give the figures off-hand; but I believe our maintenance cost on the existing houses comes to about 2½d. per ton. It is lighter on the Fiddes-Aldridge machines than on the West machines. With regard to the converted West machines, very little repairs have been done since the machines were converted. They have not been going long enough to enable me to say that they will be

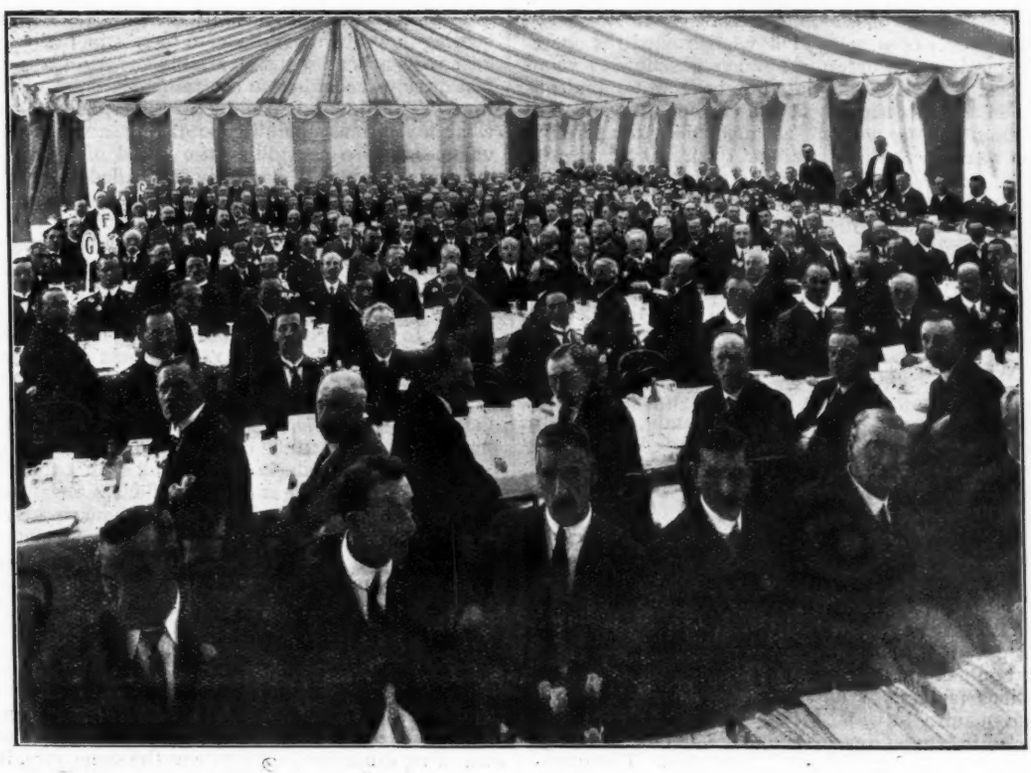
lighter, but from experience I think they will be. About the section of the retort, and the time taken for charging, the Drake's machines are feeding a 23-ft. retort, 20 in. by 18 in.; the Fiddes-Aldridge machine is feeding only a 20-ft. retort, but with the same section. We certainly get more coal into the 23-ft. retort with the Drake's machine, and that, perhaps, will account for the extra time. I think that I was misunderstood by Mr. Carr. He thought I meant that there was ground available at Beckton. We have very little ground space available there. With regard to the cost of verticals as against horizontals, I should very much have liked to have had a free hand to put the plant down in the manner I thought best; but I had not room, and had to be satisfied with the No. 7 house. Mr. Drury referred to silica segmental retorts. At Beckton we have had no trouble through carbon forming on the joints, nor have we found any difficulty at all in the pushing out of these retorts. When we increased the charges we had a little trouble. The crowns of some of the retorts were lifted, but I think this was due more to the fact that there were heavier charges than to the carbon settling on the silica retorts. As to the deepening of the producers, the results have been entirely satisfactory, and have amply repaid us the money spent on them. Mr. Gibson mentioned that he has a tube to take the coke from the retorts. I do not know whether that would be quick enough for a works of the size of those at Beckton. Perhaps Mr. Gibson would give us the time per retort.

Mr. GIBSON: They are quicker than the charging machine—about 45 seconds, I should think.

Mr. LEECH: At the same time, no discomfort was experienced with the transporter. The coke is deposited on a quenching bench out of the way of the men, and then quenched on the outside of the retort-house. I have often thought I should like a system of dry quenching. I do not know whether that is what Mr. Gibson is aiming at; but up to the present I have not been able to find anything in that way. Mr. Collett asked for the grate area of the producers. It is 15 sq. ft. With regard to fluctuations, of course, I think the chief point is that the fluctuations of temperature have been reduced. We have been able to get a good bed of fuel, which has remained so until we filled up again. The coal elevator chain has no bushes. I have considered the matter—not recently, but some time ago; but I do not think the extra cost of putting bushes in would be warranted. The chains run for a very long time. I think we have some at Beckton now that were put in in 1912; and I believe no repairs have been carried out up to the present. I know there were some put in at the Leeds works in 1904, and when I came away the original chain was still working; so that I think it would hardly pay to bush the chains. The conveyor chain referred to is not lubricated, except that the coal dust acts as a lubricant. The wearing strips are of cast iron. The last speaker asked whether I should not like to adopt the American practice of having coal lifted to the top of the retort-house by means of a belt. We spent a considerable time about eighteen months ago in getting out an elaborate scheme by which all the coal would be dealt with in this manner at Beckton. The coal was to be received by transporters and put into store by these belts, picked up by transporter, crushed at a central crushing station, and distributed to the retort-houses by means of belt conveyors. I am hoping that the scheme has not been shelved altogether, and that we shall go on with it later. The conveying of cold coke on rubber belts, of course, is quite a good thing. I think that in the paper I say that I saw a belt in America which had conveyed 800,000 tons of cold coke. I do not think we could ask for anything better; and I do not know of any other conveyor which would take anything like that quantity. The belt I saw looked only about half-way through its life. Americans have gone in for this class of belt conveyor very much, and are using it for all sorts of materials; and when I got back from America I was rather inclined to copy them.

The PRESIDENT: We are very much obliged to Mr. Leech for his interesting reply to the points raised.

THE LUNCHEON AT THE BECKTON GAS-WORKS.



A report of the visit to the works and of the speeches at the luncheon appears on pp. 784-87.

A RECORDING AND INTEGRATING GAS CALORIMETER.

By C. V. BOYS, F.R.S., one of the Gas Referees.

The passing of the Gas Regulation Act, 1920, has given an importance to the problem of finding a satisfactory recording gas calorimeter which it never possessed before. Not only must such an instrument continue to work day and night all the year round and year after year, but it should possess an accuracy exceeding that of existing calorimeters. The attainment of great accuracy is of the first importance, for the amount paid for gas in England, Scotland, and Wales in any one year is in round figures £50,000,000, so that the money value of 1 p.ct. is half a million pounds. According to the Gas Regulation Act, the amount paid by the consumers to the undertakers, except in the case of small works, is ultimately to be determined by the operation of a recording gas calorimeter, and deficiencies of 6 p.ct. or more below the declared value are similarly ascertained. For this latter reason a recording gas calorimeter subject to vagaries, though on the average correct in its readings, cannot be tolerated, for it may have a fit of depression just when the gas is below the normal in value, and bring it apparently, but unjustly, to a level which will lead to the imposition of a penalty and the greater damage caused by publication of the fact.

The production of a recording gas calorimeter for works use which will be a really useful article is one thing, but the evolution of one which will fully meet the requirements set out above, and which will command the confidence of gas undertakers and consumers alike, is quite another; and in attempting to solve the more difficult problem, I have not made light of the difficulties. While not essential, it is very desirable that the instrument should integrate as well as record; and it is all to the good if it is able to run without attention for more than a week (say, for a month).

On starting more than two years ago, I considered the different possible lines of attack, and in particular an electrical method (not the same as that found in the Thomas instrument), but ultimately concluded that any electrical device would need delicate relays and other refinements which, though tractable in the hands of a skilled electrician, would be unsuitable for use by the majority of gas examiners, who should fully understand the instruments they use. Accordingly, I followed the usual practice of the water-flow calorimeter as a basis on which to work.

Whether rightly or wrongly, I have distrusted the operation of natural law to determine either gas flow or water flow. I considered it essential that both water and gas should be doled out positively at the correct rate, and that the correction for gas volume as affected by temperature and pressure and contained water vapour should also be effected by a positive operation. These are the three fundamental quantities in a water-flow calorimeter. With these positively and accurately determined, there is not so much scope for anomalous behaviour as there is where the flow either of water or of gas is governed by natural law until the unsuspected presence of a hair in an orifice, or other anomaly, disturbs the flow for a time and until the disturbing cause ceases to act.

Water Measurement and General.

In my new instrument water is allowed to flow from a tank, where the level is maintained constant, through a nozzle into an eccentric bucket so proportioned that, when a certain quantity of water has entered, it overbalances and discharges its contents into a water-box. The bucket is caught in its overturned position by a detent so that it may drain, and is released by a clock every half-minute. The bucket then rights itself and receives water again. The bucket is supported by a wire axle subject to rolling friction only, and rights itself against an adjustable stop, so that the amount of water needed to upset it can be varied at will.

According to my general scheme of operation, I depend upon a certain definite flow of gas if measured under standard conditions (actually 1 c.ft. in two hours); and I employ such a quantity of water for any declared value that it will be raised in temperature exactly 10° C. or 18° Fahr. by the combustion of the gas if it is of that value. This quantity of water is then 2 oz. every half-minute for gas of a declared value of 540 B.Th.U. per cubic foot, and in proportion for gas of any other declared value. With this arrangement, and with a scale on the record sheet of (for instance 1 in. for 1° C. or for 10 p.ct. of the calorific value of the gas, or $\frac{1}{10}$ in. for 0·1° C. or 1 p.ct., I obtain the same record for corresponding percentage departures from the declared value whatever this may be; and records from different sources of widely different declared values are all strictly comparable. The declared value, of course, is represented by the middle line of the sheet, and the scale of inches is also a scale of degrees centigrade, which is convenient when verifying the operations of the instrument. Two inches on either side of the middle line—*i.e.*, 20 p.ct. above or below the declared value—appear to me to be ample.

The water doled out every half-minute falls into a box of two compartments, passing from one to the other through a small hole, and out of the second through another small hole. By this means the fluctuation of rate of flow every half-minute may be made very slight and its effect on the record invisible; but the desired result of an exact and adjustable average flow positively ascertained is very perfectly attained.

The jet of water which misses the bucket when this has tipped over and is so held passes into a second water-box, similar to the first with two compartments. All four compartments are constructed in celluloid as one piece. Celluloid is also employed for the measuring bucket.

The water leaving the waste water pair of compartments, which may conveniently amount to 1 or 1½ oz. every half-minute, passes over a small overshot water-wheel (also made of the same convenient material), and turning once in half-a-minute. This water-wheel supplies the motive power to drive, through an elastic connection, the escapement of a one-wheel pendulum clock ticking half-seconds. It also turns, through intervening mechanism, the axle of a gas-measuring device on which the measuring drum is loose. As the intervening mechanism has the effect generally of gearing-down the speed in the ratio of 6 to 1, the axle turns generally at a speed of one turn in three minutes. If then the measuring drum and axle turn at the same rate, a capacity of 1/40 cubic foot per turn is required for the drum.

The Thinking Machine.

The intervening mechanism just mentioned while in general gearing-down in the ratio of 6 to 1, is in reality a variable gear with a continuously variable range of about 10 p.ct. fast or slow, according to the value of the gas volume at the time. This device is positive in action, and from its somewhat mysterious operation in taking account of the gas volume, and so controlling the speed of operation of the measuring device, I have always called it "the thinking machine." It contains a small ball-disc-cylinder integrator of the kind invented by James Thomson (brother of Lord Kelvin), coupled with epicyclic double reduction gear. This gear, which is the part that makes the operation appear mysterious, gears-down the motion of the disc in the ratio of 3 to 2 and the motion of the cylinder in the ratio of 15 to 1, or 10 times as much. The disc is geared-down from the water-wheel in the ratio 4 : 1. The motion of the cylinder is determined by the position of a 1¼ in. Hoffmann bronze ball, which itself is determined by an air bell over mercury and water, so that for a change of gas volume of 10 p.ct. it moves 1 in., equal to the radius of the cylinder, and in proportion for other values. The result is that the axle of the meter is kept rotating at a speed which is the algebraic sum of the two reduced speeds. The cylinder is at rest when the gas volume at the time is 1·000. The meter axle is, therefore, kept turning at a speed exactly proportioned to the gas volume; and this is the result of a positive mechanical drive which may be made correct to one-tenth of 1 p.ct.

Gas Control.

As I have said, the measuring drum is loose on the axle but screws on to it, so that if it and the axle turn at the same rate there is no endlong movement. But if the measuring drum does not rotate at the same rate, it screws along one way or the other; and this endlong movement is utilized to control the gas-inlet orifice. If the drum is turning faster than the axle, it moves along to reduce the gas entry, and *vice versa*. If the axle is prevented from turning

(as, for instance, by stopping the clock), the drum screws along and shuts-off the gas. If, however, the gas is cut-off instead, the drum screws the other way up to a stop on the axle, after which the axle, in attempting to turn the drum, meets with such a resistance in the absence of a gas supply as to stop the clock. If thereafter the gas supply should be resumed the drum screws along to the other end of its restricted run, and shuts-off the gas. Thus whatever may happen, there can be no danger from escape of gas. The bucket never does fail to right itself; but if, owing to the enterprise of a mouse or other interference, the bucket did fail to do so, the water would continue to flow into the second water-box supplying the water-wheel. It would appear that in that case the calorimeter deprived of water but not of gas would be overheated and destroyed. This is not so, for the two to three fold increase of water to the second water-box raises the level of the water therein, and the excess escapes through a hole into the first, and so back to the calorimeter after all.

GAS VOLUME RECORD.

The fork which directs the rolling of the ball along the V groove formed by the incline disc and the cylinder of the thinking machine carries a pointer moving over a scale of gas volumes, so that a gas examiner can observe if the air-bell is correctly placed in its annular mercury bath, and correct it if it is not. It seemed to me most desirable that a record should be kept of the movements of the pointer, so that after any severe changes of temperature or pressure evidence might be forthcoming that the necessary correction for volume had in fact been made. I have accordingly provided a small recording drum with a peculiar epicyclic drive, which converts a rotation of one turn a minute into one of one turn a month for this purpose. It would unduly lengthen this paper to go into the mechanical details of this or of the thinking machine; but I feel I am justified in expressing a certain satisfaction in having produced this pair of elements which constitute one of the most important units in the design. Mechanicians may be interested in this drum and its mounting, as well as in the means used for driving it, for it provides an easily made general-utility recording drum for laboratory use with a wide range of speeds. While this recording drum is in no way essential to the working of the calorimeter as a whole, I feel that its advantages more than outweigh the few shillings that it will cost. The gearing-down of the water-wheel to the epicyclic axle operating the drum and the other epicyclic axle driving the disc of the integrator, is effected by the use of a sprocket wheel of 9 teeth engaging with sprocket wheels of 18 and 36 teeth and a sprocket chain sold by the Meccano people. This is the third time recently within my knowledge where the admirable fittings of these people, made and sold for toys, have found a place in a highly-refined scientific instrument.

THE METER.

So far I have only mentioned, but not described, the drum of the gas-measuring device. The meter in my arrangement does more than measure gas; it doles it out at the desired rate by positive volume measurement and at atmospheric pressure, and it is also its own governor. The construction of the meter differs greatly from anything I have seen, and very much to the advantage of the user. He can see every part when working; he can get at the interior and take it all out if he wishes to do so, and put it back. But no question of replacing parts should arise, as I believe it to be everlasting.

The casing consists of a cast brass ring closed below by a spun copper bowl and with a flange above turned truly plane. This is covered by a glass bell with a ground edge, smeared with vaseline, resting direct on the brass flange. This junction is below the water-level, so no leakage of gas is possible, and experience shows that water does not escape at all. The axle works in a long sleeve, which slides into a hole in the brass ring and is clamped in position, and the axle and sleeve are both made water-tight by vaseline, which can be forced in round both by a single Stauffer grease-cup. The axe then is free to turn, but water does not, as a fact, ever leak at either of these joints. There is no other place by which water can escape as a liquid. It does not escape as vapour, because the gas before entering the meter passes through a Woulfe's bottle filled with wet material, so that the gas here takes up water of saturation or, if super-saturated, deposits excess water. By this means the water-level in the meter indicated by one or more upturned points under the water is prevented from changing.

Moreover, the construction of the drum is such that if it did change the capacity of the meter would be very little affected. The drum itself also is peculiar, in that I have made it of celluloid (a most admirable material for the purpose); and the inlet and outlet aprons of the usual wet meter drum are replaced by discs which close the front and back of the usual four compartments. The gas enters and leaves the compartments through passages half-an-inch square in cross section at the periphery of the drum. Instead of leaving the interior of the drum open as usual, I close in about two-thirds of the length of the drum from the front end by means of a buoyancy chamber, from which the four usual sloping partitions radiate. By this means the weight of the drum is largely carried by the water, and not by the axle, which merely locates it. A far more important advantage is gained, in that the gas in any compartment at the moment at which it is trapped and measured is contained in a chamber of which the sides, ends, roof, and about two-thirds of the floor are defined and independent of the water-level, while a small part only of the floor is formed by water. Thus, as I have already said, a change of water-level has very little effect on the capacity of the meter, and the water-level does not change. The means of observing change, if any, are far more delicate than the usual water line on a window. I hope in this way to be able to avoid the tiresome operation of proving the meter and the resulting disturbance of the record.

The gas has no work to do in turning an axle in a stuffing-box, any increase of which increases the gas-passing capacity of a meter, for the axle is turned by the power of the water-wheel. The gas pressure has only to turn the drum in the water; and this is not only inappreciable, but constant in amount. For these reasons, the meter is (I believe) far more accurate than any that has yet been made. The burner is a plain open-ended silica tube $\frac{1}{8}$ to $\frac{3}{16}$ in. in diameter, but a back-pressure of about $\frac{1}{8}$ in. is thrown upon the meter by the inclusion in the pipe between the meter and the burner of a No. 2 or No. 3 Bray rat-tail burner. This is necessary only to prevent the gas-flame from being extinguished by the slamming of a door. The pressure of $\frac{1}{8}$ in. of water or thereabouts in excess of the atmosphere is inappreciable in comparison with the 33 ft. of atmospheric pressure.

From the foregoing description, it will be seen that the meter, besides measuring the gas, serves as a means for doling it out at the desired rate at atmospheric pressure, and that it is independent of the density of the gas. It is all the same to this meter if hydrogen, acetylene, carbonic oxide, or coal gas is supplied. The same volume corrected for temperature and pressure will always be doled out; and no pre-governor is needed, though one may with advantage be employed. The drum is provided with a celluloid boss front and back, of which the front one only is tapped to run on the screwed axle. I have used $\frac{7}{16}$ in. Whitworth, $\frac{1}{4}$ in. Whitworth, and a No. 3 B.A. thread on different drums I have made. Any of them works quite well, and will I believe prove to be everlasting. I desire to refer with the same degree of satisfaction to this meter that I have to the thinking machine which directs its operation, for the solution which the combination offers of the problem of dealing with temperature and pressure and supply of gas is complete. The measurement, doling out, and corrections are mathematically true in principle, mechanically sound, and positive. The apparatus is easily made and everlasting, and the correction is infinitely variable with the weather.

While there is no reason why the meter drum should not be made with the exact capacity specified, this is not essential; for if it should be found to be (for instance) 1 p.ct. too great, it would merely be necessary to adjust the stop of the water-bucket so that it delivered 1 p.ct. too much water. I do not know if it would be useful to a gas-works engineer for his station meter to register the gas passing through it corrected for temperature and pressure in addition to his ordinary record. If so, a gas-bell and thinking machine within the meter between the drum and the counting train would enable him to attain this result.

HEAT INTERCHANGER.

The heat interchanger and operative thermometer system also differ from usual practice. The water from the first pair of compartments of the water-box is led into an open-down flow tube 3 in. in diameter at the upper end, in which

is placed the cold operative thermometer. The water passes down to the base level, and then enters a water-ring at the base of the hot-water compartment, made of thin German silver. In the lower part of this is a small heat interchanger, by means of which the heat of combustion is transferred to the water. This interchanger is made of thin sheet lead, so that the acid products of combustion may not compass its destruction.

The sheet lead is closely folded radially into 15 zigzags round a central combustion space, and the form of the zigzags is such that there is a set of extremely narrow up-cast water-ways on one side of the sheet, and a set of voluminous down-cast gas-ways on the other side; and only one longitudinal joint is needed to complete the separation of the water from the gas-ways. The separation of the combustion space from the down-cast gas-ways is effected by the loose contact of the inner folds sealed by water of condensation. At the lower end the adjacent sides of each water-way are pinched together and autogenously soldered, and a flat ring of lead is soldered round the interchanger near its lower end. This is clamped between a thick brass ring and the woodite ring on the base casting, to make a water-tight joint. At the upper end the water-ways are cut-off at about 45° and autogenously soldered—all except three, which are continued higher up so as to carry a small dome of fused silica. This does not corrode, but it becomes so hot directly above the flame that water does not condense upon it and drip perhaps on the burner. Over all a dome of sheet lead is moulded so as to fit the periphery, and is soldered in position. I have writen a special note on autogenous soldering at the end of this paper. The hot-water compartment is divided in the middle above the interchanger, and the separated parts are joined by a narrow neck through which the water flows, and which supports the hot operative thermometer in the upper part. This separation and neck serve to prevent a curious and unknown phenomenon of a calorimeter showing more heat than is produced by the combustion of the gas. This would take too much space to explain; but it must be mentioned.

On reaching the top of the hot-water compartment, the hot water, raised 10° C. in temperature whatever the declared value of the gas may be, as already explained, passes out through a tube and through an extensive worm exposed to a strong draught, so as to be cooled before entering a tank with the water wheel tail water, to be pumped and used over again. The lead interchanger can at any time be taken out and cleaned, examined, or replaced by unscrewing nine pinching screws and three holding-down screws. The down-cast combustion gas and condensed water pass into an annular lead trough, and so out below the shelf on which the calorimeter stands. The acid drip is led to a drain, and not to the lower tank. The air for combustion is drawn from the cold-water side of the casing, so that it and the cold water are at the same temperature and, with the gas for combustion, are all at the temperature of the room. For this reason a room not exposed unduly to sun heat, but as uniform in temperature as possible, should be chosen. A dry basement in a substantial building, and one facing North, would be most suitable. I have devised means to maintain the moisture in the air for combustion up to 6/7 saturated or other desired value; but at the present time I think it best to leave such refinements until the main instrument gives me some leisure.

The Operative Thermometers.

The hot and cold operative thermometers are identical in construction. Each consists of a piece of brass tube 3 in. long and $2\frac{7}{8}$ in. in diameter, with the upper and lower ends closed by means of corrugated brass or copper lids most carefully soldered on. To the middle of the lower end of each a small brass cone is soldered to rest in a conical seat and support the thermometer. To the middle of the upper end a spigot or filling block is soldered, which can be hermetically sealed after filling with liquid by forcing in a taper steel pin, thus constituting an un-refillable bottle which cannot be tampered with. The liquid I have used is commercial amyl-alcohol, which is inexpensive and has the merit of having a high "A" co-efficient of expansion and an unusually small "B" co-efficient. It is also non-corrosive and unalterable. The thermometers are easily filled by means of a capillary funnel; and if spun rapidly any air within comes to the centre and escapes. If these thermometers are sealed after being filled as described, bubbles will be heard to rattle in them if shaken after cold weather, owing to dissolved air escaping under diminished pressure. I have found that this difficulty is overcome by keeping the filled thermometers before sealing under the receiver of an air pump and in a dish. Quite a lot of liquid slowly comes out owing to the evolution of dissolved air. They may then be filled again and sealed, or exhausted a second time and filled and sealed.

Thermometers of this construction are wholly immersed in the hot or cold water, and no part is exposed to any other temperature. The expansion of the liquid is insistent, and not a mere persuasive push as with air; and (what is not often realized) the co-efficient of expansion is very nearly one-third that of a gas, so that far more is gained by the irresistible force than is lost on account of diminished expansion.

Insulation.

The insulation of the hot-water compartment is far more important than it is in usual forms of calorimeter, because of the small amount of gas being burned ($\frac{1}{2}$ c.ft. per hour instead of 5 c.ft.), and because of the relatively large surface to be jacketed.

I am able by a device to obtain the effect of an absolutely perfect insulator without any insulation at all; but it is advantageous to use cotton wool or flannel about $\frac{3}{4}$ in. thick. The device is this. Near the upper end of the hot-water compartment a massive brass ring is soldered, and round the neck a split-ring of willow wood is tied. Round these two a thick sheet of copper is wound very tightly and wired on, and the insulation is tied on outside this copper. The copper reaches down below the neck to that level at which the rising hot water is rising in temperature very rapidly. The effect of this construction is to surround the hot-water compartment by a jacket of almost exactly the same temperature as itself, and a small part at the lower end by a jacket of higher temperature. Thus there is hardly any radiation or loss of heat from the hot-water compartment, and there is a gain lower down equal in amount to the very small loss. Further, the small amount of heat which traverses the large cross-section of the insulation is derived not from the hot-water compartment where it surrounds the thermometer, but from the water which has done its work and is about to leave the instrument. The calculation of the several quantities is identical with that of a leaking submarine cable, being graphically represented by a catenary curve or calculated by hyperbolic functions.

The whole water system is enclosed in a wooden casing with a partition separating the hot and cold sides, and this is closed above by a lid. The casing serves as further insulation, and it carries the water-box above and other parts not yet described. The thinking machine and some other parts are carried by cantilevers, which are in one with the base upon which the water system is screwed. The meter is separate, and is connected to the thinking machine by a loose Hook's joint.

The Magnifying Lever System.

As the thermometer bulbs are 3 in. long and the co-efficient of expansion of amyl-alcohol is 1-1000 in round figures, a perfectly fitting piston would move ·003 in. for each degree C. of change of temperature. A corrugated cover expands more nearly in the parabolic form, and so moves half as much again—*i.e.*, ·0045 in. about for each degree of temperature, or ·00045 in. for 1 p.ct., so we are faced with the position that a two-thousandth of an inch means half a million pounds.

The two-thousandth of an inch is certain enough in itself, but the means for converting this into a movement of 1-10th in. of a pen moving on paper must be very perfect in its design if this is to be accomplished with certainty. It is easy to say a magnification of 222 or thereabouts is all that is needed; it has to work, and not be ambiguous or stick.

With the irresistible expansion of a liquid, I believe I have an easier problem in my lever system than that so well solved by those who depend upon the expansion of the more elastic air. This is made evident by the rigidity or rapidity of oscillation of my pen when disturbed, and its well-defined position of rest.

The magnifying lever system must have a double function; it must magnify the expansion of the cold-water thermometer as well as that of the hot-water thermometer, and subtract one from the other so as to record the excess of temperature only. According to my present plan, I accomplish this by calling in aid the third dimension of space, as will be apparent. The top of the hot-water compartment is

closed by a disc of brass carrying two pairs of pillars notched at the top which form the fulcra of two parallel primary levers each magnifying 2⅓ times. These reach outside the casing, terminating in the same transverse plane. From one of these (the hot one) hangs in a vertical direction a balanced bell-crank lever by an edge at one end of its short arm, while at the other it is caused to press-up against the end of the other primary lever, which is held down on its fulcrum and on the point of the cold thermometer by a strong spring.

The bell-crank lever is continuously adjustable as to its magnification by having its short arm controlled in length by a screw. The lower end of the bell-crank lever is connected by a tie to a point on the short arm of the pen lever. This short arm is discontinuously adjustable over a large range to give extended capacity to the instrument. The axis of the pen lever is vertical, but the link just mentioned is at right angles both to the primary levers and to the long arm of the bell-crank lever, which is also vertical, thus acting in the third dimension of space. By this means, if both thermometers rise or fall in temperature together, the bell-crank lever merely falls or rises 2⅓ times as much, but does not cant, and so no effect is produced upon the pen lever; but any differential heating moves the pen lever an amount proportional to the difference only. The setting of the pen is effected by micrometer screws on the thermometers, and the degree of magnification by adjustment of one or other of the short arms of the bell crank or pen lever. As the primary lever of the hot thermometer is pulling it up and its buoyancy in the water supports most of its weight, I prevent this from rising off its conical support by a pair of annular lead weights in the water which prevent also loss of heat by undesirable convection currents.

It will be apparent from the foregoing description that the whole of this delicate lever system is loose and floating. Any part can be removed by just lifting it off, but when put back it recovers its former position absolutely. The same is true of nearly every part of the whole machine. Nothing is locked in place unnecessarily or soldered-up or hidden away out of sight. In this respect I have no sympathy with the instrument maker who treats the user of an instrument with scant consideration, as one who must not be able to get at any part if it can be helped, or be allowed to see the operation of any part that can be hidden away out of sight. I am, and always have been, my own instrument maker, so that I consider my own convenience as a user; and I see no reason why in the present instance I should treat the gas examiner who may have to use this instrument any less favourably. The instrument in use is not a portable one; any part put in place will remain there if the design is right—gravity will see to that. In the classical words of Miss Helyett in the French play, "the laws of gravity are inexorable;" a thing will stay where it is put. We do not screw our chairs and tables to the floor except on board ship; a chemical balance manufacturer could not imagine a balance with the beam held in its place; and I see no reason for interfering with the precision or convenience in use of a machine in order that the user may not see its operation or do things with the greatest facility.

The Recording and Integrating Mechanism.

The axis of the pen lever (as already mentioned) is vertical, and rests by a pivot on a jewel if desired. The greater part of its length is in the form of a lantern to contain the integrating mechanism. At the upper end of the lantern arms hold upturned points 3 in. apart, upon which the pen arm and attached ink supply rest. The pen system is almost exactly balanced on these points, so that it barely presses on the paper. The pen consists of a fine silver tube 9 in. long, leading from the ink supply to the writing-point about an inch above the ink. Sufficient ink for a year is easily carried. The ink which I have prepared never dries on the pen; and on one occasion when the pen had been raised off the paper for 31 days, it went on writing at once when lowered again. This may seem a small matter, but practically it is important. The single clock axle carries a worm engaging with a worm-wheel of 60 teeth on a cross-shaft, which turns once in half-a-minute, and anti-clockwise in direction as seen from the front. This cross-shaft carries a worm near the front end engaging a worm-wheel above it of 48 teeth at the end of the recording drum, which accordingly turns once a day, and having a periphery of 6 in. moves the paper ¼ in. per hour, or 42 in. per week—a convenient amount. The cross-shaft at the other end carries a worm turning an integrating drum below it 2 in. in diameter also once a day. An integrating wheel of the same size on the Amsler principle carried in the lantern, and in part balanced by a counter-weight, rests lightly on the integrating drum. Its face is divided into 100 parts.

With the dimensions and proportions indicated and the pen lever 10 in. long, the meaning of the reading on the integrating wheel is this: If after any length of time since it was last set to zero a certain number of divisions have been integrated—*e.g.*, 5—it means that over the whole period the gas has been of its declared value except for 5 days, when it was 1 p.ct. high, or for one day when it was 5 p.ct. high, or changed about in any kind of way, but so that its average value would be represented by a 5-day 1 p.ct. excess. Similarly for divisions in the negative direction due to corresponding deficiency.

There is, therefore, all the time a plain figure visible from the front, which shows how much the gas undertaker has to make up or has in hand, in order that at the end of the quarter no question shall arise as to an unpalatable return to the consumers in a subsequent account, or, on the other hand, that the gas undertaker need not be unduly generous and give away unnecessarily his valuable commodity.

The paper passing over the recording drum may be perforated by holes spaced an inch apart engaging with 6 teeth on the drum; but I prefer plain paper unruled and unperforated, so as to avoid trouble due to the paper getting slightly displaced or the ruling on it not being true to the line of sprocket holes. Plain paper then passes over the drum turning once a day, and pressed into contact therewith by a roller in front. A group of pens, in the form of syphons of silver tube, bring ink from a group of inkwells made in one piece in celluloid to the paper, and the writing ends are located by a properly perforated plate. As the paper moves along, the lines are ruled in position determined by the perforated plate, which is a definite part of the machine, and irregular feed of the paper is immaterial.

The ruled lines and the record line are necessarily in proper relation. Similarly the time scale is marked on every one of the ruled lines by giving the perforated plate a lateral movement of about $\frac{1}{100}$ in. every half-hour by means of a cam on the cross-shaft. The particular half-hour marks at noon and midnight may be distinguished from the rest and from one another by allowing the perforated plate to be limited in its lateral movement by the end of the record drum, where notches or projections can be arranged to give any time pattern. By setting all the ruling syphons ¼ in. behind the recording pen it is merely necessary to see that the perforated plate makes its time indication one hour too soon for this to correspond with the record. Thus the paper may be ruled with lines of different colours or shades, each one of which is a time scale, as well as a line on the scale of calorific values, and the position of the paper, so long as it keeps moving on, is immaterial. The cross axle at its front end carries a spur wheel of 20 teeth (20 diametrical pitch), and two pins in front of this wheel engage alternately with the teeth of a wheel of 48 teeth. This carries an hour hand, and shows the hours on a clock dial.

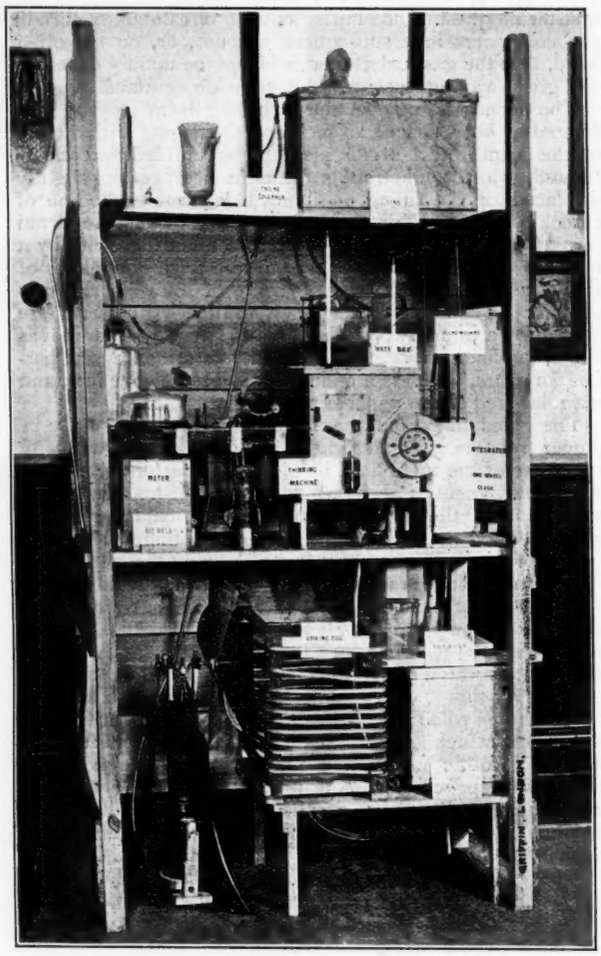
A concentric wheel of 40 teeth, driven by the wheel of 20 teeth, carries a minute hand reading on the same dial. The proper going of the clock is itself an indication that the mechanism as a whole is working correctly; and this clock of one wheel has the advantage that it goes indefinitely without being wound, and it serves as a counter for the gas-meter as well as a clock.

The Adjuncts of the Calorimeter.

The whole instrument stands on a shelf 3 ft. 6 in. long by 2 ft. wide; but I have made a kind of whatnot, with such a shelf at a convenient height and two other shelves, one below and one above, to carry tanks, which, though not essential for the working of the calorimeter, are very desirable.

It must be remembered that the amount of water needed for all the recording calorimeters that may be required in London alone is very considerable, and that in the case of recording calorimeters using much more water than mine the cost of the water would amount to nearly £20 per annum for each calorimeter. This is not the only objection to the constant running to waste of the company's water. Quite apart from the obvious objection to the waste in such a year as the last, there is always the possibility—and in country places the greater probability—that the supply may fail or be cut off intentionally. Further, the constant passage of water no harder than that which we have laid on

in Victoria Street, Westminster, gives rise to deposit of lime, not only in the warmer parts of the hot-water compartment, but even in the cold-water side on every soldered joint. I have no experience of acid water or peaty water; but the constant flow of this I believe to be undesirable. By the use of two tanks of moderate dimensions—*e.g.*, 10 gallons or so—and means for pumping the water from the lower to the upper tank, the difficulty is at an end. In order to pump the water, I am using as motive power one of those beautifully made hot-air engines with Hoffmann ball bearings made by the Model Engineering Company, of No. 8, Addison Avenue, W. 11, which are used so largely for fans in India, and which, unlike the punkawallah, do not go to sleep, but work steadily on night after night and year after year silently and without trouble. The flywheel of the engine is also a fan, and this supplies the draught of air to the cooling coil.



Boys' Recording and Integrating Calorimeter.

At first I arranged for the automatic starting of the engine whenever the level of the water in the lower tank reached a certain mark, when the whole of the water was pumped to the upper tank in four minutes. I have, however, replaced this by a continuously running pump directly coupled to the engine and running at about 120 turns a minute.

A float on the water in the upper tank controls the gas for the burner of the engine to which this pump is directly coupled, so that the rotation of the engine is maintained at such a rate that the water level in the upper tank does not change. This governing is quite unnecessarily precise; the addition of a single ounce of water to the upper tank affects the governor at once, which adjusts the running of the engine until the level is set right. While it is repugnant to any engineer to keep a machine running night and day all the year round and year after year, the simplicity of the arrangement, and the durability of the two machines ambling round at a low speed and with so small a load, appear to me the more economical course. The upper tank should be provided with a ball cock connected with the water service, so that the supply may not fail if anything should happen to the pumping mechanism; and an overflow should be provided from the upper tank to the lower, and from the lower tank to a drain, in case the ball cock should leak. The suction of the pump is taken through a very fine copper gauze, which may be sufficient to prevent the growth of low organisms of any kind, and will certainly save particles from blocking or damaging the pump.

If this copper treatment is not sufficient to destroy the life of lower organisms, a grain or so of sulphate of copper put into the water at long intervals certainly will.

The gas used by the engine is about $1\frac{1}{2}$ c.ft. per hour; and this is only part of the gas which I believe every gas company would desire to have burned in order to keep the gas in the service-pipe alive, and so the pumping is done at no expense for fuel. The remaining extra gas should be used for ventilation. I have said nothing as to the means by which every operation of the instrument may be checked by reference to standard thermometers or measuring vessels. I think this is obvious, and that the inclusion of such details would unduly lengthen this already lengthy paper, and weary members of the Institution who have been so kind as to give me the hospitality of their journal, for which I tender my best thanks.

I see two likely developments of the instrument which I have described; but I shall not be able to make any trial in these directions until the more important recording and integrating instrument is established. The first of these is a non-recording or "spot test" calorimeter. For this the operative thermometers, lever system, integrating and pen frames, and recording drum would be absent. The thinking machine would be replaced by a mere 6 to 1 or other reducing gear, and the air bell would be absent. The water supply, clock, and meter would remain, and the large cold and hot water compartments would be replaced by tubes of sufficient size to hold standard thermometers. This would lead to an inexpensive calorimeter, very easy to use, accurate, and speedy in its indications. Probably 10 or perhaps 15 minutes would be sufficient before taking readings on the mercurial thermometers.

The integrating and recording calorimeter as described, but without meter, air bell, and thinking machine and heat interchanger, might, with advantage, be used with a bomb calorimeter in the place of the interchanger, and with increased pen magnification and speeding-up of the integrator. With such a combination the bomb would be put in place, and the water current established and left for an hour or so, until the record showed a straight zero line. Then the bomb would be fired, and the integrating wheel read. After an hour, or whatever the time might be when the record had returned to be a continuation of the original straight zero line, the integrator would be read again. The difference would at once give the heat developed, and this could be checked by heat electrically developed and measured, which also is always an alternative method for checking the working of any recording gas calorimeter.

The record would show the manner in which heat was evolved. The bomb might be replaced by an animal in an enclosure, for physiological investigation or other continuous and varying source of heat. Physiologists might also find the meter and thinking machine useful for air measurement.

NOTES ON LEAD BURNING.

Autogenous soldering of lead, or lead burning as it is generally called, presents difficulty when the lead is very thin.

In the case of the interchanger described, where a number of joints have to be made close to one another, and the thickness is 0·035 in., the heat from a flame used on one joint is apt to melt the lead of another. I have overcome this difficulty by the use of a cool flame, which will barely melt lead at all, but which ensures a reducing atmosphere at the point of operation. The welding is effected by intense local heat formed by a wee arc. The lead is the positive pole, and a pointed carbon the negative pole.

The current is produced by the 200 volts available, and it is steadied by a resistance of 200 ohms or more. The carbon is moved by hand at a distance of about a millimetre from the lead, and at a rate of about a foot a minute, and hydrogen and CO_2, supplied by two large Kipps generators, are fed on to the arc.

To ascertain the proportion of the two gases, I turn on the hydrogen first to a mixed oxy-hydrogen jet, and then turn on CO_2 gradually until a fine shred of lead still melts, but a

piece of the sheet lead is not melted when the flame is directed upon it. Without the reducing flame I have found that the pieces refuse to join.

Perhaps coal gas would do as well as hydrogen, and a hollow carbon to feed the gas would be a convenience. These gases at least will not fire back as an oxy-hydrogen mixture does.

The PRESIDENT: Gentlemen, we have had a very great treat [Hear, hear]; and we thank Prof. Boys very sincerely for bringing this apparatus to the notice of the scientific world through the medium of our Institution, though he had previously made up his mind to give the paper to some society composed of more highly learned men than we are supposed to be. The apparatus itself is a marvel of simplicity and ingenuity—in fact, it is so ingenious as to be almost uncanny. Of course, I do not say that about the inventor. [Laughter.] New and novel methods have been adopted for the measurement of the gas, for the burning of the gas, for the regulation of the water, for the observation of the heat, and for the recording of the result, and, with Prof. Boys at my elbow, I feel that in this apparatus we seem to have attained success. If it is so, after a thorough examination by several independent observers, we will not only congratulate Prof. Boys on his wonderful success, but we will also be very greatly indebted to him for giving us an apparatus which will prove of the very greatest benefit to the industry. At the time it was determined to change over from charging per 1000 c.ft. to charging per therm, I think it is quite possible that it was thought there would be no difficulty in prescribing a recording apparatus suitable for measuring the calorific value of the gas. This, however, was found to be a difficult thing; but it is very advisable that we should have it. Now that we are charging by the therm, we want to know exactly what therms we supply; and if Prof. Boys has been successful in giving us this apparatus, we are indeed very much indebted to him. With regard to the remarks he has made as to the cost of some of the parts of the apparatus, we might imagine that we shall be able to purchase these machines for a £5 note. We can only hope that it may be so. [Laughter.] At any rate, there is in the apparatus a large amount of work. It is a wonderful construction; and I shall be very glad indeed to hear what our men who have gone into this type of apparatus more carefully than myself have to say about it. The paper is now open for discussion.

Mr. GEORGE HELPS (Nuneaton): You all have the advantage of me this morning, because your scientific minds are able to grasp the simplicity of this highly scientific instrument. I have no doubt whatever that it will do all that Prof. Boys claims for it; but I pray heaven I may never have to use it. [Laughter.] I do not understand it; you all do [renewed laughter]; I never shall. If the change-over to charging by the therm, or calorific value, in lieu of illuminating power, necessitates such an instrument as this, and what must be included with the instrument—the various people who will be trained to use it—I would prefer to go back to the candle power standard, and try to devise some instrument that would show me a minus quantity. When Prof. Boys brings his great abilities to bear on this instrument, I pray earnestly that he may be able to take out of it many of the parts it now contains. From the consumers' point of view, I am perfectly certain that it will be of very little value. When we tell the consumer—the industrial consumer or the small householder—that this instrument informs him we are supplying the quality of gas we should do, I think he will say: "I won't have anything to do with it. All I know is that the missus could boil the water for the tea this morning in the proper time." I submit to you, gentlemen, that there is a lot to be said for that argument. We want to get down to a simple instrument that will satisfy the consumer he is getting all he pays for. I am confident, as a burner-maker for a number of years, that we can get down to the point where we can show the consumer, within a very small percentage, that he is getting something like the quality he is supposed to be paying for. I think that is what we should aim at. Why not a device which will enable the consumer to say that the gas to-day will boil a quart of water in so many minutes, and so on? It would satisfy him much more than being told by some highly scientific Government official that the test was quite all right. I take this instrument as an example of the mind of the gas industry to-day—involved, chaotic. I am no scientist, and do not pretend to be. But I do know that if a man states as a scientific fact something very complex, which cannot be understood by the man in the street, it is not the highest science; and we want to get down to the simple facts associated with this matter of satisfying the consumer. I look upon this instrument also in another way. It shows me how fast we are going towards a quality of gas of something like 200 B.Th.U. If we were satisfied, and if we could satisfy the Government and the consumer, that we were treating them fairly, we should be satisfied with a test within 5, 6, or 7 p.ct.; I myself would go to 10 p.ct. If you send out a 600 B.Th.U. gas, this would mean 60 on your gas; and if 200, it means 20. There is something in that.

Dr. J. A. HARKER, F.R.S.: I was one of those who had the privilege yesterday morning of being present at a demonstration by Prof. Boys of his most ingenious recording calorimeter, which, in my view, it is only fair to say, marks a new era of progress in calorimetry. I have also read the paper. Without illustrations, which I believe are to accompany it ultimately, it is a little difficult to follow. The many novel points about the design, which obviously represent the survival of the fittest, after long practical experience, are most interesting. The delightful and altogether splendid lecture he has given us this morning has made us all absolutely enthusiastic about the great triumph he has achieved. On the whole, I think the outstanding feature of the instrument is the great care which has been taken throughout to eliminate any mechanism, or the use of any material, which cannot be depended upon to go on doing its duty without deterioration over a long period of time, without being constantly nursed and looked after. The use of silica and of thin lead, also the very novel method of soldering joints in thin lead, are most important. Then there is the use of that extremely convenient material, celluloid, which has not entered into the construction of instruments to anything like the extent it might. All gas engineers know how very rapidly copper, brass, &c., degenerate, especially in the presence of gases containing sulphur. It is most annoying, after an instrument has been working quite satisfactorily for some considerable time, to find that it is essential to dismantle it for cleaning, and in nine cases out of ten, on re-erection, you find some discrepancy or altered behaviour has occurred. Often one is quite uncertain as to how far back the alteration really took place. The care which Prof. Boys has taken to make the whole thing of homely, durable materials—not, perhaps, fool-proof, but accident-proof—is most evident to anyone who has had experience with the usual types of flow calorimeter, and who knows their vagaries. The author's remark about the significance of the 1 p.ct. accuracy in buying and selling gas deserves the most careful consideration of engineers, as well as the explanation of the use and value of the integrating device. By means of this the gas undertaker can see exactly what he most wants to know—how he stands with the consumer. The calorimeter, instead of being a mere policeman, becomes his friend, doing for him the work of a whole staff of observers and computers, and keeping his "pass-book" posted right up-to-date. I shall certainly look forward to being able to make, at some future date, a more intimate examination of this most useful instrument, which has just come along at the psychological moment for extensive application in the gas industry. More than twenty years ago, when Prof. Boys gave us the quartz fibre, he was regarded by physicists as perhaps the most skilled experimentalist living. The combination of physical, chemical, and mathematical skill with the highest constructional ingenuity, which is shown in the new calorimeter, has proved that his brain and his hands have still retained their well-known cunning.

Mr. J. L. HODGSON (George Kent, Ltd.): The last speaker referred to the wonderful calorimeter shown this morning as an example of the survival of the fittest. I submit that this is not the case, but that we are at the beginning of the recording calorimeter rather than having arrived at the end of it. As an instrument maker, I deeply appreciate the wonderful instrument we have seen; but I feel that it is extraordinarily complicated, and agree with the first speaker, who is not a scientist or instrument maker, that one ought to get down to something simpler. I will make one criticism—if I may be so bold as to criticize Prof. Boys. The method of compensating for the temperature and pressure variation of the gas does seem to be more complicated than is the case with another calorimeter on the market. In that case, a single shaft run at a uniform speed pumps a given quantity of gas and air to support the combustion, and air to produce cooling. The fact that the cooling is done by air automatically allows for variations in pressure and temperature, because if the barometer goes up and the pressure of the gas gets greater, there is greater weight of cooling air put through the cooling apparatus than if the barometer is low; so that there is no necessity for any complicated compensating arrangements for pressure and temperature. I have not seen the particular calorimeter; but I would much like to have Prof. Boys' criticism of it, as to why the complicated method of getting compensation in Prof. Boys' instrument is better than that used in the particular instrument I have referred to. Going through Prof. Boys' calorimeter in detail, I think one could find many points that could be simplified, because, though one may have produced an instrument that will work satisfactorily, it can be simplified after some years of use. My own experience of this kind of work will suggest that the small Bray burner will cause trouble. If moisture gets into the burner, the surface tension of the moisture will immediately stop the flow of gas. This is a rather dangerous point. As to the use of celluloid, I find that it is a material which is very liable to warp. For the water wheel, however, it is perfectly satisfactory.

Mr. J. H. CANNING (Newport, Mon.): I think we are to be congratulated on having such an excellent paper presented to us, and also on the fact that our industry has secured the aid of such an eminent authority. I should like also to say that we have seldom been favoured with so interesting a paper on any subject; and Prof. Boys, I think, on this occasion is to be congratulated upon the possession, simultaneously, of two qualities which are not very frequently combined—namely, the highest scientific ability, with a keen sense of humour. With regard to what has been said by one speaker, that perhaps this instrument, being of a somewhat high scientific order, is not exactly the most fitted for the condi-

tions of gas supply, I do not think there can be any agreement if we consider the case impartially and carefully. We have suffered a good deal in the past from not having possessed these instruments of high scientific accuracy; and if we look to our competitors, we see them using every day instruments of a far more complex kind than the one placed before us. Personally, although I quite agree that the highest form of ingenuity has been used in this instrument, after all it is of a simple description, and the devices used are exceedingly ingenious and not liable to get out of order. There is one matter upon which, I think, we can all learn a lesson in this instrument. Personally, I have been greatly struck by the exceedingly careful way in which Prof. Boys has adjusted his material to the purpose for which it is used, and especially in the use of a metal which is practically non-corrosive, where the calorimeter is exposed to the products of combustion. In the ordinary gas-burner we find that there is not a similar adjustment of material for the purpose, and consequently we are very apt to suffer from such a fact. The average inverted gas-burner, after being in use for a comparatively short time, becomes adorned with crystals of the sulphates of the various metals of which it is made, and not only that, but when this corrosion is set up it finally destroys the burner—its life is shortened, the consumer is dissatisfied, and I feel, incidentally, a great many of our troubles are due to this cause. But, to come to one particular point upon which I trust Prof. Boys will be able to give us a little information, I notice that the thermometers he employs for the purpose of registering the temperature, which form a very important part of the instrument, are of the type in which an expanding liquid acts upon a flexible diaphragm. I have had a little experience with that class of instrument, and have generally failed eventually through (shall I call it?) a diminution of the elasticity of the metal. This may be liable to occur; but I have not the slightest doubt that Prof. Boys, who has shown such ingenuity, has provided some method either of calibrating these thermometers or adjusting them in order to overcome the difficulty I have suggested.

Prof. BOYS, replying to the discussion, said: I have very little to say. I do not think the observations made by Mr. Helps concern me very much, because he does not understand anything about it; and I only say that you cannot make a silk purse out of a sow's ear. [Laughter.] The observations of Mr. Hodgson are more interesting. He, as an instrument maker, understands the difficulties of instrument construction, and he has referred to one method of compensating for temperature and pressure. It is a good way of compensating for temperature and pressure; and this is another good way of compensating for temperature and pressure. I am not, for the moment, prepared to say that this is vastly better than the other way; but I think it is a very good way. As for being difficult or complicated, I do not allow the expression of "complication" as applied to the little "thinking machine." That is a thing which, as a manufactured article, is of the most extremely simple kind to make, and it does not matter whether Mr. Helps can understand it or not. The thing will work. It does not matter if the gas examiner cannot understand it; all he has to do is to leave it alone. [Laughter.] It is quite simple for the man who makes it to understand how to make it, and put it together, and it will remain right. An attack has been made on my use of celluloid. I do not care a bit about attacks on celluloid; it is constantly being used for purposes such as that for which I have used it. In the first place, we are told it is inflammable. I have been allowed, justly, to use it for the water-wheel; but it is said it is no good because it warps. Because it warps, I have made the drums of a form that did not necessitate loose aprons. As to danger from fire, I do not know how any light or fire is to get into the meter. There is copper all round, and brass below and above, so that inflammability is not of the slightest consequence. I use celluloid for the water-box because it works so easily and quickly, and it is transparent. But there is no reason why the water-box should not be made of copper. When a man comes along with a big cigar, and wipes the end off on a celluloid box, and sets it on fire, he says what a dangerous thing celluloid is. [Laughter.] Of course it is, under those conditions; but there are many other dangerous things. I thank Dr. Harker for what he said; but there is nothing to answer. There is another very important observation; and I am very much obliged to Mr. Canning for having made it. I have neither mentioned it in what I have written, nor did I mention it this morning. He said he has had experience of these complicated devices for thermometers, and that the elasticity is a source of trouble. Supposing these boxes had been filled with air, and they had been kept in use, then we are using a material which is elastic within, which has to withstand very great variations of atmospheric pressure on the surface for so many points up or down from time to time. Any variation of elasticity of one as compared with the other will completely ruin the operation of the instrument; and the wonder to me is, having looked into the problem very thoroughly and quantitatively, and with figures, when I started operations, that those who have used the air thermometer have got things to work as well as they have. But these are filled with liquid. The liquid will occupy so much volume, and the length is compulsorily made that which the volume imposes. I believe that is a complete answer to what you have suggested.

NATIONAL GAS COUNCIL OF GREAT BRITAIN AND IRELAND.

Fourth Annual General Meeting.

The Fourth Annual General Meeting of the National Gas Council took place last Thursday afternoon, in the Connaught Rooms, Great Queen Street, W.C., under the presidency of Mr. D. MILNE WATSON.

The minutes of the special and third annual meetings, held in December last, having been circulated, were taken as read, confirmed, and signed.

LOSSES BY DEATH.

The PRESIDENT then referred to the great loss that they had suffered during the past six months by the death of the Rt. Hon. Sir Daniel Ford Goddard, Mr. G. R. Hislop, and Mr. Isaac Carr, and more recently by the lamented death of Mr. Walter King, of the "GAS JOURNAL." Two of these gentlemen, he said, were honoured members of the Council, and were deeply interested in its affairs. They would be much missed. Mr. King, of course, was not a member of the Council; yet he followed with the greatest interest all its doings, and no man had a more intimate knowledge of the industry than did Mr. King. He (the President) thought they as an industry were very happy in having possessed in Mr. King, as Editor of one of the great technical journals connected with the industry, a man who was so upright and straight, who always followed the truth, and did not "trim to the passing breeze."

THE REPORT AND ACCOUNTS.

The following report was submitted, together with the statement of accounts.

ALTERATION OF CONSTITUTION.

At the annual general meeting held on Dec. 14, 1921, the constitution of the Council was altered for the purpose of making the years of the different constituent bodies coincide; and the new financial year of the Council was made to cover a period from April 1 to March 31. This necessitated a transitional period of six months only, which is the period now under review.

GAS REGULATION ACT.

Section 1.—During the period under review, 67 gas undertakings have lodged applications with the Board of Trade for a revision of their standard or maximum price under section 1 of the Act; and 114 Orders have been granted.

Section 10 (*Special Orders*).—During the same period, 29 gas undertakings lodged applications under this section, with a view to extending the powers conferred by their Private Acts and obtaining additional powers. The Council have scrutinized the clauses in these Orders, and have successfully prevented the opponents of these applications from inserting provisions which might prove detrimental to the industry.

Sections 4 *and* 5 (*Testing of Gas*).—It is with pleasure that we announce that the Gas Referees have made an amendment with regard to the qualifications of Gas Examiners, in their Memorandum issued to local authorities appointing such officials. The Draft Prescription of the Gas Referees with regard to pressure testing has been submitted to the Council for their consideration and suggestions. This important question is having the most careful attention of the Council.

Board of Trade Returns.—The Council protested against a proposal of the Treasury that the publication of the Board of Trade Returns relating to Gas Undertakings should be discontinued. This proposal, if carried out, would have deprived the gas industry of the only official statistics available. Members will welcome the announcement that the Treasury have now sanctioned the continuance of these publications, upon the understanding that the deficit (if any) is in future to be charged to the gas fund formed under the Gas Regulation Act.

SAFEGUARDING OF INDUSTRIES ACT, 1921.

(*a*) *Gas Mantles.*—In spite of the fact that, owing to the efforts of the Council, gas-mantles were excluded from the scope of Part I. of the Act, a complaint was lodged that the mantle-manufacturing industry was a "key" industry, and that imported gas-mantles were, or should be, liable to duty under this part of the Act. In the ensuing legal proceedings, it is satisfactory to report that the contention of the Council was upheld, both by the Referee and the Divisional Court.

(*b*) *Heat-Resisting Glassware.*—A complaint was lodged under Part II. of this Act by manufacturers that, by reason of the depreciated exchange, they were entitled to 33⅓ p.ct. duty upon imported heat-resisting glassware. The Council, in conjunction with the London Chamber of Commerce, opposed this application, and gave evidence before the Committee appointed to hear the complaint. No decision has yet been given.

OTHER MATTERS.

Electricity (*Supply*) *Bill.*—A great amount of work has been undertaken by the Council to secure the modification of this Bill during its passage through the House of Lords. Several amendments were moved on behalf of the Council; and though these themselves were

not accepted, considerable modifications have been obtained in connection with some of the clauses that were most detrimental to the gas industry.

South Wales Electrical Power Distribution Company's Bill.—This Bill proposed, *inter alia*, to authorize local authorities within the limits of supply of the Company to invest the money of the ratepayers in the ordinary capital of the Company, whose finances were such that the promoters themselves have admitted that the capital of the Company (amounting to £610,120) is unrepresented by available assets to the extent of £457,590. Having regard to the importance of the principle involved, the Council agreed to assist a large number of gas undertakings in South Wales which were lodging a joint petition in opposition to this Bill. Counsel were briefed to contest the Bill in the Committee of the House of Lords. Certain safeguards were obtained; but the Council were not successful in obtaining the entire deletion of the objectionable clause.

Draft Regulations, Factory and Workshop Act.—A further revised draft of the regulations has now been received from the Home Office; and the Committee appointed by the Council for this purpose have been carefully investigating this revised draft. The Council were still dissatisfied with certain features in the revised draft, and put before the Home Office an amendment of considerable importance. The Home Office, unfortunately, did not accept the amendment, but have written and stated that the Chief Inspector of Factories will himself consider applications for exemption from the operation of the regulations, and be prepared to grant certificates of exemption in suitable cases.

Revision of Railway Rates.—The Council have been indefatigable in their efforts to obtain immediate voluntary reductions in the carriage of coal, coke, &c.; and certain concessions in this respect were obtained from the English and Welsh railway companies. Further endeavours have been made—unfortunately without success—to obtain the extension of like concessions to gas undertakings in Scotland. The Council, however, were not content with the reductions granted by the railways; and a deputation waited upon the railway managers for the purpose of obtaining more generous treatment for the gas industry. The railway companies have now announced further small concessions. Furthermore, the Council have, in conjunction with the Association of British Chemical Manufacturers and the Federation of British Industries, placed a case before the Railway Rates Advisory Committee in connection with the classification of traffics in which they are particularly interested. Considerable concessions were obtained in connection with the classification "Group 9—Chemicals."

Workmen's Compensation Insurance.—The arrangements entered into by the Council with Lloyd's underwriters to insure this risk for the gas industry upon particularly favourable terms have already shown a very large saving to members. Up to the end of the period under review, 129 undertakings have completed policies with Lloyd's; and the saving effected by 97 of this number is no less than £4135 per annum. This represents in the case of a number of undertakings several times the amount of their subscription to the National Gas Council. The amount of saving effected by the remaining 32 undertakings is not known. In addition to the 129 undertakings referred to, several members have been able, as the result of Lloyd's quotations, to effect large reductions upon the existing rates of premium with their present insurers. The amount of the aggregate saving in these cases is not available; but it is known that in one case it amounted to between £700 and £800 per annum, and it is estimated that a further saving of £3000 per annum has been effected by these undertakings. Since the end of the period under review, these figures have been considerably increased.

Standardization of Cookers.—The final report and specification has been approved and adopted by the Committee. The amount of care and attention that has been devoted to this work will be evident from a perusal of the report, which contains suggestions which, if adopted, should provide the means of effecting large economies both in the initial cost of cookers and the expenditure needed for maintenance and the storage of spare parts. Since the end of the period under review, the report and specification have been approved and adopted by the Central Executive Board.

Sulphuric Acid and Spent Oxide.—This matter is now occupying the attention of the various districts of the Council.

Corporation Profits Tax.—Owing to the fact that the exemption which all public utility undertakings had obtained from this tax expired on Dec. 31, 1922, it became necessary for the Council to endeavour to induce the Chancellor of the Exchequer to continue such exemption. The Council understood that the Chancellor did not propose to grant any exemption from this tax in the future; so that it became essential that the strongest case should be put forward for the continuance of such exemption. United action was organized among the public utility Associations concerned; and a joint memorial was forwarded to the Chancellor, setting out in detail the grounds for their claim to exemption. Since sending the memorial, members will have noted with satisfaction that, in introducing the Budget, the Chancellor has promised to extend the exemption of public utility undertakings for a further period of three years.

General.—The work undertaken by the Council in connection with legal advice and general assistance to gas undertakings continues to increase. The subjects dealt with are too varied, and the cases too numerous, to set out in a report; but there is no doubt that the industry in general has greatly benefited thereby.

District Executive Boards and Management Committees.—The valuable assistance given to the Council in the past by the District Executive Boards, Management Committees, and District Secretaries, has again been rendered unstintingly, thus enabling the Council faithfully to reflect the views of the industry as a whole.

Monthly Reports.—The monthly reports issued by the Council would appear to be increasingly appreciated by members. In addition to keeping them in touch with the activities of the Council, the issue of these reports has proved a useful means of effecting economies in connection with postage.

Damage to Gas-Mains.—Owing to complaints received from certain members as to damage caused to their mains by reason of heavy traffic, and of reduced accessibility thereto in consequence of the use of concrete or reinforced concrete for road construction, a Sub-Committee was appointed to investigate the whole subject. Since the first meeting of this Sub-Committee, informal negotiations have been opened with the Ministry of Transport, with a view to safeguarding the interests of gas undertakings in connection with the above matter.

Meter Testing.—The Council have been successful in inducing the Standards Department of the Board of Trade to amend the instructions issued to Gas-Meter Inspectors in regard to meter testing and the certificates given in respect of such tests. The Memorandum issued by the Board of Trade will have the effect of simplifying the procedure and removing a frequent cause of friction between gas undertakings and their consumers.

Income.—The total amount received by the Council by way of joint subscriptions to the National Gas Council, the British Commercial Gas Association, and the Institution of Gas Engineers (for research work) during the period under review amounted to £37,772, of which a sum of £10,279 is retainable for the purposes of the National Gas Council. The majority of the subscriptions received cover a period up to Sept. 30, 1922, but in a few cases cover a period up to March 31, 1923. To the above figure of £10,279 there must be added interest—viz., £83—making a total of £10,362, of which £4458 has been carried forward to meet the expenses which will be incurred during the financial year 1922-23. The income of the National Gas Council in respect of the six months ended March 31, 1922, is therefore £5904.

Expenditure.—The expenditure of the Council for the past half year amounted to £6450. The net deficiency on the Council's working for the six months is therefore £546.

Reserve Fund.—The sum of £1120 shown last year as the balance of the reserve for the purchase of suitable furniture for the Council's Offices at No. 30, Grosvenor Gardens, has been reduced to £943. The sum of £1000 set aside towards the expenses connected with acquiring the premises in question is still in reserve.

Membership.—49 undertakings have joined the Council during the period under review, making a total membership of 877 gas undertakings.

THE NEW FINANCIAL YEAR.

The PRESIDENT said it would be remembered that at the special meeting of the Council which was held last December, certain resolutions were passed with a view to making the financial years of the constituent bodies coincide. The Council, the British Commercial Gas Association, and the Institution of Gas Engineers now made up their accounts to March 31 of each year; and the members had been called together to consider the report and the statement of accounts for the transitional period of six months ending on March 31 last. They could have postponed the meeting until this time next year; but the Executive thought that was too long a period to allow to elapse before rendering an account of their stewardship. Therefore they had called the members that day to what was really an interim meeting, to report for the past six months; and after that things would go on for a twelve months period. Though it was only six months since they last met, he thought they would agree that the interval had been occupied with work of considerable importance to the industry. He was pleased to say that during this period no less than 49 additional undertakings had joined the Council, which had now a total membership of 877 undertakings, representing between 90 and 95 p.ct. of the gas made in the United Kingdom. So he thought they might claim to be a truly representative national body.

THE GAS REGULATION ACT.

Turning to the different headings which they saw in the report, perhaps for many of them the Gas Regulation Act was still the most important feature. The difficulties which confronted them at their last meeting had been very largely overcome; and those undertakings which were then waiting for their Orders under Section 1 had found that they had not been penalized as a result of the inevitable delay consequent upon the rush of applications. Up to the beginning of the present month, over 250 Orders had been made; and it was thought that every case where severe hardship was being experienced had now been dealt with. Most of the undertakings which had had their Orders would also have received the Gas Referees' Prescription with regard to testing for calorific value; and they would, he thought, be satisfied that, while ensuring to consumers all the safeguards to which the Gas Regulation Act entitled them, the Gas Referees had not made unreasonable demands upon the industry. Their Prescription regarding pressure testing had been the subject of discussion with the Council; and he was sure that their views would be carefully considered by the Referees before any final decision was reached.

SAFEGUARDING OF INDUSTRIES BILL.

At the last meeting, he told the members that the Council were dissatisfied with the wording of the Safeguarding of Industries Bill, so far as it related to gas-mantles; and he expressed the fear (which, unfortunately, the Government did not share) that the Schedule to the Bill was so indefinitely drafted as almost certainly to lead to a claim being made for the inclusion therein of gas-mantles. This fear had proved only too well founded; and much time and labour had been expended in opposing the claim of the Incandescent Mantle Manufacturers' Association that a duty should be imposed upon imported gas-mantles under Part I. of the Act. Proceedings had also been taken by the manufacturers to render gas-mantles and heat-resisting glassware liable to a further duty of 33⅓ p.ct. under Part II. of the Act, upon the ground that these articles could not profitably be manufactured in this country, owing to the depreciation of foreign currencies in relation to sterling. The Council opposed both these applications. With respect to gas-mantles, no Order had yet been made.

The Committee appointed to consider the question of glassware had, however, unfortunately made an Order imposing a duty in respect of certain types of illuminating glassware which were manufactured in Germany. No duty, however, was imposed upon glassware manufactured in any country other than Germany. The Council were strongly of opinion that the cost of gas lighting should not be artificially increased, if it was successfully to compete with electricity.

THE ELECTRICITY (SUPPLY) BILL.

Since the last meeting, the Electricity (Supply) Bill had passed through the House of Lords, and, as they knew, was now engaging the attention of the House of Commons. The progress of the Bill had been carefully watched by the Council; and in its present form the Bill was, at any rate, much less inimical to the interests of the gas industry than when it was originally introduced. As an industry, they had never feared legitimate competition upon equal terms. Their opposition was directed to exceptional treatment being accorded their competitors. The gas industry did not ask for subsidies from the rates themselves; but, as large ratepayers, the gas companies objected to being called upon to contribute towards the cost of competitive and speculative electrical schemes.

FACTORY AND WORKSHOP REGULATIONS.

Turning to the regulations issued by the Home Office under the Factory and Workshop Act, members would recollect that at the last meeting the Council were able to report the elimination of nearly all the objectionable features in the original draft. In the interval, negotiations had continued with the Home Office; and the Council had received an assurance that the Chief Inspector of Factories would himself consider applications for certificates of exemption from the operation of the regulations, and that these would be granted in all suitable cases. The Council were satisfied that it was not the intention of the Home Office to place harassing or unnecessary obligations upon small gas undertakings, where the chemical processes incidental to gas manufacture were quite subordinate; and they had withdrawn their opposition to the regulations as now drafted. Every undertaking which felt entitled to exemption from these regulations should immediately upon their publication communicate with the Council's officers.

RAILWAY RATES.

Another question of considerable importance to all members was that of railway rates. The Council had been most insistent in endeavouring to obtain concessions from the railway companies in regard to the high rates prevailing on the carriage of coal and coke. He was glad to say that, so far as England and Wales were concerned, these endeavours had met with considerable success. The railway companies had made two reductions since the last meeting; and, as members were aware, not only had the flat-rate increase been halved, but considerable concessions had been obtained in connection with both the percentage and maximum increases. It was most disappointing to the Council—and he spoke with feeling, as a Scotsman—to have been unable to obtain any reductions in railway rates in Scotland. Endeavours were still being made to secure concessions on behalf of the Scottish gas undertakings. Important as was the subject of railway rates, and the closely related question of the reclassification of goods and merchandize, he did not propose to deal with these matters at length on the present occasion, as detailed information on this somewhat technical subject had appeared month by month in the Council's reports.

STANDARDIZATION OF GAS-COOKERS.

Many of them would by now have received the final report and specification of the Committee appointed to consider the important question of the standardization of gas-cookers. It was a matter with regard to which they had, he was afraid, been called upon to exercise considerable patience; but a careful perusal of the report would, he was sure, satisfy them that their patience had been rewarded. It would have been most discouraging to the Committee—and, in his opinion, detrimental to the interests of the industry—had the Council pressed for an early decision upon a matter of such great importance as this question of the standardization of gas-cookers. In undertaking this work, the Council were animated with the sole desire to collect and combine those ideas which experience had shown to be most satisfactory, and at the same time, by simplifying the problem of maintenance and replacement, to relieve the industry of the burden of heavy expenditure which in recent years had become so serious. The Committee commenced their investigations with detailed particulars of the requirements of the members throughout the length and breadth of the land; and as a result they claimed—and he thought justly so—to have combined in one type of cooker all those features which led to economy in prime cost and maintenance, efficiency in use, and adaptability to the requirements of the several districts.

WORKMEN'S COMPENSATION INSURANCE.

In the report which was presented at the last general meeting, reference was made to the negotiations which were taking place with regard to a reduction in the rates of premium in respect of workmen's compensation insurance; and the hope was expressed that a scheme would shortly be forthcoming which would mean a considerable saving to the industry. If proof were needed of the value of co-operation in these matters, it would, he thought, be provided by the tangible result which had been brought about within the past six months. As the outcome of a great number of interviews with representatives of the various insurance interests, it was found that Lloyds offered terms which represented less than one-half the charge made by the Tariff Insurance Companies. Since the fruition of the scheme, no less than about 150 undertakings had taken advantage of the reduced rates obtainable. A number of claims had been made and promptly settled; and in no single instance had the Council had a complaint as to any quibbling on the part of Lloyds' representatives. On the contrary, they had had several letters bearing witness to the prompt and generous settlement of all claims that had been made. The direct saving in premiums under Lloyds' policies had already amounted to no less than £5000 per annum. In addition, as the result of competition, the rates quoted by insurance companies had been reviewed; and though they were still materially higher than Lloyds' rates, they represented a saving to members upon the premiums hitherto paid of approximately £4000 per annum—showing an aggregate saving of £9000 a year. Without an organization such as their Council, this result would have been impossible of achievement. Individual firms in other industries whose risk was no greater than that of the gas industry were to-day paying premiums from 60 to 70 p.ct. higher than those which the gas industry had been able to obtain. Their preferential position in this respect was solely the result of co-operative action. Some of their members, it was interesting to know, had made an actual cash saving in premiums of from five to ten times the amount of their subscription to the Council; and numbered among these were undertakings who doubted whether the state of their finances was sufficiently sound to permit of their subscribing to the Council at all.

CORPORATION PROFITS TAX.

The time at disposal did not permit him to deal in detail with the various ramifications of the Council's activities to which reference had been made in the report before the meeting. There was one subject, however, to which he must allude in passing—namely, the promise of the Government to exempt statutory gas undertakings from the incidence of the corporation profits tax for a further three years. United action was organized among all the Public Utility Associations concerned. A joint memorial was prepared with extreme care, and forwarded to the Chancellor of the Exchequer, who, realizing the strength of the arguments adduced, had provided in the Finance Bill for a further extension of the concession previously granted.

WIDER SCOPE OF THE COUNCIL'S WORK.

From perusing the report for the period under review, all members would, he thought, be impressed with the vast difference in the scope and character of the work undertaken by the Council, in comparison with that attempted when the Council first came into existence. It was only a few years ago that the Council came into being for purely defensive purposes, in consequence of the exceptional financial crisis which had arisen in the industry. To-day, however, the Council were no longer purely on the defensive. They had recaptured lost ground, consolidated their position, and were now thrusting forward to take their rightful place in the forefront of industry. Success, however, could not attend their efforts unless every undertaking and every member was imbued with the spirit of effort and interest in connection with the work of the Council. Members must not only seek assistance, but be prepared to render it when their time came. They must not rest content with the progress that had already been achieved. The Council desired that everyone should follow with the closest attention the policy adopted and steps taken by them, and that they should lose no opportunity of proffering suggestions or tendering advice. In this way, they would always be quite sure that the industry would not stagnate, but be vitalized and re-vitalized year by year.

In conclusion, he had much pleasure in moving that the report and statement of accounts for the six months ended March 31, 1922, as circulated, be approved and adopted.

Mr. WILLIAM CASH said the President had asked him to second this resolution—mainly, he thought, in order that he might say something with regard to the accounts appended to the report. These he proceeded to explain, remarking that it would appear that they ought to continue to have at least the subscriptions they were getting now; and having regard to the benefits which accrued from membership of the Council, he hoped there would be an increase. He said he would like to endorse what the President had stated with regard to the usefulness of the organization. In connection with two matters alone which dealt primarily with finance—the corporation profits tax and workmen's compensation insurance—the members had reaped a direct financial advantage from the operations of the Council during the past twelve months.

COST OF ROAD REINSTATEMENT.

Mr. HILLS (the Chairman of the East Grinstead Gas Company) said he would like to draw attention to a matter which was of importance to companies operating in small urban and rural districts. In his particular area, the Company were allowed to open roads for the repair and extension of mains, and for the laying of house services; but they were not allowed to reinstate these roads. Before tar macadam and other things were introduced, the cost to the Company of the reinstatement was perhaps 2s. to 2s. 6d. per yard, whereas it was now from 8s. to 10s. The Councils would not permit the Company to reinstate the roads,

but did it themselves, and charged the Company with the expense. He was glad the National Gas Council had taken this matter up, and trusted they would not allow it to drop, but would impress upon the authorities that some allowance ought to be made owing to the changed circumstances that had arisen since the mains were first laid. Undertakings should not have to pay four or five times what they used to pay, when they extended facilities to their consumers.

The PRESIDENT said it was a very important question, which would not be lost sight of.

The report and accounts were then adopted.

MUNICIPAL UNDERTAKINGS AND THE REGULATION ACT.

Alderman F. S. PHILLIPS (Salford) said that, with the President's permission, he would like to take the opportunity of making an announcement which would perhaps have some interest for municipalities owning gas undertakings. The position with regard to the Gas Regulation Act might be said to be very different in the case of a company from what it was for a municipality. It might have been noticed that few corporations had so far made an application to come under the Act. He had been requested—and he proposed to carry out the request—to ask municipalities owning gas undertakings to meet to consider their attitude with regard to the Act. In the course of the next few days he would be inviting those who represented municipal corporations to meet and discuss the position.

THE PRESIDENT'S ACKNOWLEDGMENT.

The PRESIDENT said that, before the meeting broke up, he would like to propose a hearty vote of thanks to the Chairmen and Secretaries of the District Boards. At the end of his remarks on the report, he had made an appeal for help from everyone. No Executive, however active, could do all the work themselves. They had specially to thank the Chairmen and Secretaries of the District Executive Boards for their great work during the past six months.

The vote being unanimously passed, the members separated.

ASSOCIATION OF TECHNICAL GAS OFFICIALS.

Temporary Suspension of Operations.

At the Third Annual General Meeting of the Association of Technical Gas Officials, held in the hall of the Institution of Electrical Engineers, London, last Thursday—Mr. R. G. SHADBOLT presiding—it was decided to suspend operations temporarily, but that the Association should remain in being. There was a very poor attendance; and this led to a suggestion that it was necessary that there should be a quorum. It was pointed out by the Chairman, however, that there was no rule regarding a quorum at a general meeting, except where special business had to be transacted, in which case a quorum of fifty was necessary.

The CHAIRMAN, submitting his report of the past year's working, said he did not feel very elated at having to give the meeting anything in the nature of a report, for the simple reason that the efforts of the Association had not been so successful as it had been thought they might be. The efforts to interest representatives of the administrative side of the gas industry to the extent of getting them to agree with the Association on a minimum scale of remuneration for technical gas officials, had not succeeded. The result of the deliberations, generally, was that those gentlemen could not see their way to adopt the minimum scale. They preferred to deal individually with technical officials in their particular undertakings; and this was an expression of so emphatic a character that it was useless for the Association to attempt to go further. The Executive Committee had tried to devise ways and means to incite interest in the Association and its objects; and one means which it had been thought would tend towards this end was the opening of a discussion in the Technical Press on the subject. He, as Chairman of the General Council, had written a letter to the Technical Press, in order that expressions of opinion might be obtained from all kinds of people connected with the industry. He would like to take the opportunity of acknowledging that the comments in the editorial columns of the Technical Press were all that could be desired. ["Hear, hear."] They were favourable, they were couched in impressive and emphatic language, and they had shown, at any rate, that the Technical Press realized the situation, and that the existing state of affairs was in many cases a very weak spot in regard to the industry. But in spite of this, there was very little response. What did all this point to? It meant that there was a great amount of apathy on the part of the administrators of the gas industry; and there was apathy shown on the part of many of the technical gas officials, to whom the Association might legitimately look for support. In face of this apathy on both sides, it was very very difficult to continue; and added to this was the fact that, with the present membership and rate of subscription, the funds were not sufficient to enable them to carry out the objects of the organization. The Association was crippled for want of funds, and for want of interest. The Executive Committee had been, very reluctantly, after considerable thought, forced to the conclusion that the Association could not continue on the present lines. Finances were low, and the membership had not grown; and if an increase in the rate of subscription were suggested, it was fair to assume that new members would not be obtained, and that the Association would probably lose some of its existing members. In face of such conditions, the Executive Committee would recommend that the affairs of the Association be suspended for twelve months. In the circumstances, was it better to continue to beat the air vainly, more or less, or was it better to acknowledge the inevitable, and conclude that there was no scope for the operations of the Association at present? The results of the operations of the past year were so discouraging that they did not see how the Association could exist very much longer. As to the financial position, the statement which had been circulated to the members would show that at the end of March last (the close of the financial year) the Association was in possession of 10s. 7d. Since then, however, the liabilities had increased to £42 12s., against which there was £3 7s. 10d. on the other side of the account. To enable the Association to carry on, the salary of the Acting Secretary had had to be guaranteed. Also, on March 31, £42 was still outstanding, which was due to the late Secretary. He proposed the adoption of the report and accounts to March 31 last.

Mr. R. H. BROWN (late of Birkenhead) associated himself with the remarks of the Chairman. There were about 800 engineers in the country, roughly 500 company men and 300 in the service of municipalities, while there were ten at the meeting. Company men, generally speaking, had little reason for complaint; while the municipal employee had every cause. He had recently cut himself adrift from the industry, mainly due to the fact that municipal engineers had no society to support them in times of difficulty. He had been in trouble with his Corporation; and there had come a crisis, which was dealt with in the "GAS JOURNAL" (June 21, p. 675). Had there been a society to support him, he believed the present state of affairs would not have come about. He dealt with the political animosity which existed in many towns, and expressed the opinion that unless municipal employees had a body to beat the political association in the town, a large number of those in municipal employment would not survive. With regard to the present position of the Association of Technical Gas Officials, he saw no option but to close down temporarily.

Mr. F. G. SHAW (Buxton) considered that it should certainly be known that the Association had been able to do a great amount of good for its members. The correspondence had been considerably heavier than one would imagine from the present state of affairs; and, owing to the wave of economy which is now sweeping over the country, and the suggestions as to reductions of salaries, there were a good many instances in which the Association had been able to help the engineers concerned. Necessarily the work done had to be confidential; but it was a pity that it could not have been more widely known. The organization of such a profession as that of the gas industry presented very great difficulties; and the number of possible members was more limited if the membership was confined to technical men only. It had been the view of himself and others that if the Association had originally contained within its ranks all gas officials—technical, administrative, and commercial—it would possibly have had a better chance. With regard to the recommendation of the Executive Committee to suspend operations, it was hoped that the present members of the Association would continue to support it, so that its indebtedness could be paid off, and a certain amount be left in hand to help make another start. The operations of the Association had been good for the whole industry. There was nothing in the Association which was antagonistic to the National Gas Council or the Federation of Gas Employers. The Association simply desired to bring before them the bad cases in the industry, of which there were a good many, to prevent inadequate remuneration and a low standard in technical men. They all wanted to make their great industry greater still; and he felt that they might have had more sympathetic consideration from the administrators of gas undertakings.

The report and accounts having been adopted, consideration was given to the recommendation of the General Council, which was put forward in the form of a resolution, as follows:

> That the affairs of the Association be suspended for twelve months; and at the end of that time the present Executive Committee shall meet and decide the course to be adopted.

Mr. F. C. BRIGGS (Dudley), who is Chairman of the Executive Committee, as well as Acting Secretary, moved the resolution with reluctance. He bore out the remarks of Mr. Shaw in regard to the help which the Association had been able to render members during the past twelve months. There were cases in which members of the Association, who had been faced with reductions of salaries, had not had their salaries reduced, whereas other employees of their corporations had suffered reductions. The Executive Committee had worked hard during the year to get into

touch with the other organizations in the industry. It had been suggested that a proposition should be put forward that the Association be affiliated or taken over by the Institution of Gas Engineers; and nothing would please the Executive Committee or the General Council more. But when it came to anything definite, they were left in the cold. Why should not the Institution help to prevent engineers having to work for a mere pittance? In twelve months there might be great need for the Association.

Mr. J. WILSON (Motherwell and Wishaw) seconded the resolution, on the assumption that if the activities of the Association were suspended, subscriptions would come in as usual.

The CHAIRMAN said that the liabilities were somewhere about £100. If the Association were to close down altogether, there would have to be a levy on the members; but if, instead, the members would send in their subscriptions in the normal way, the liabilities could be met, and there would be a little in hand to enable the Association to carry on when operations were resumed. If the resolution were passed, the organization would be kept in being, but would be in a state of suspended animation.

Mr. W. G. S. CRANMER (Willenhall) asked what means would be adopted for keeping the present members together during the suspension of activities. He also pointed out that, if the administrators of the industry had been aware that education was one of the objects of the Association, they would perhaps have been more sympathetic.

The CHAIRMAN said they were in possession of the rules of the Association; and these had also been set forth in the Press.

The resolution was carried unanimously.

Mr. SHAW then moved that the Association should extend its membership to all grades of gas officials—technical, administrative, and commercial—and that the rules be altered to give effect to this. He believed, he said, that in the next few months circumstances would cause a great revival of interest in the Association, and particularly he was of opinion that a great deal of the present difficulty was due to the fact that the membership at the commencement was not sufficiently wide. If his proposition were carried, in the meantime, while the operations of the Association were suspended, the machinery could be prepared for extending the membership when the time came to push forward.

Mr. A. S. BROOK (Lisburn) seconded. In many of the smaller works, he said, there were trained assistants applying for positions, and getting them, irrespective of any fixed scale.

The CHAIRMAN suggested that the resolution be re-drafted, in order that it might be an instruction to the Executive to consider the matter.

Mr. WILSON expressed the opinion that the work being done by the Association should not have been delegated to that body at all. It should have been shouldered by the Institution of Gas Engineers. He had not given up hope that the Institution would eventually see the error of their ways. If the Association were to widen its scope, it would not be in such a strong position in getting the Institution to father the whole business. If the membership were limited to technical officials, there would be nothing against the Institution taking up the work.

Mr. BROWN supported this view.

Mr. JAMES DICKSON (Johnstone) also supported, and said that the time would come when the Institution would give more heed to the Association. There was no doubt a great need for an Association which would encourage engineers to give good, straight, honest service, which would redound to their own credit and that of the people they served. The Association was founded for the benefit of technical gas officials; and (in thanking the Chairman for the very able, strong, and loyal manner in which he had conducted operations) he said it had been of real service to himself.

Mr. BRIGGS, in supporting Mr. Wilson's view, said there was no reason why the Institution should not ultimately do the work. He suggested that the Institution should have a sub-body of technical gas officials to deal with salary matters.

With the concurrence of the mover and seconder, the resolution was re-drafted, and was finally carried as follows:

> That this meeting recommends the Executive Committee to consider the question of extending the membership to all grades of technical, administrative, and commercial gas officials.

A hearty vote of thanks was accorded the Chairman and the Executive Committee.

Income-Tax Calculations.—Shortly many companies will be preparing their interest and dividend warrants for the six months ending June 30. As the rate of income-tax has been reduced from 6s. to 5s. in the pound as from April 6, it is important that the actual rates in force during that period should be reckoned when deducting income-tax. The "Financial Times" has prepared a table giving, in a simple and very easily ascertainable form, the exact amount to be deducted from dividend payments of any amount up to £1000. By adopting this method rather than by averaging, there is a saving to companies of $\frac{1}{8}$ p.ct. The price of the table is 2s. net, or 2s. 3d. by post.

Fire Prevention.—The series of Red Books of the British Fire Prevention Committee dealing with the tests on the fire-resistance of plain and reinforced concrete, carried out with assistance from the Department of Scientific and Industrial Research, is now complete. The series, numbering 31 volumes, has been published by H.M. Stationery Office, the total cost of the individual volumes as published being £4 7s. 6d.

REGISTER OF PATENTS.

Automatic Valve for Geysers.—No. 179,083.

VAN GEERT, M., of Brussels, and VICTORY CONSTRUCTIONS MÉCANIQUES, SOCIÉTÉ ANONYME, of Antwerp.

No. 13,980; May 18, 1921.

This invention relates to an automatic valve for geysers and the like, which allows not only to adjust the minimum permissible temperature of the hot water and to obtain any temperature above the minimum, but also to modify the supply of gas in relation to the volume of water to be heated, so that the volume of water obtained may be altered without variation in its temperature.

The valve is of the type wherein a piston or plunger placed in the valve body for the water moves under the influence of a depression produced in the piping, and draws with it a rod which in its turn raises the admission valve for the fuel. The rod is formed in two sections; the adjacent ends of the sections are provided one with a left-hand, the other with a right-hand thread; and the ends are connected by a suitably threaded sleeve, so that when rotating the sleeve in one direction or the other the sections of the rod move away from or towards each other, thereby accelerating or retarding the admission of the gas.

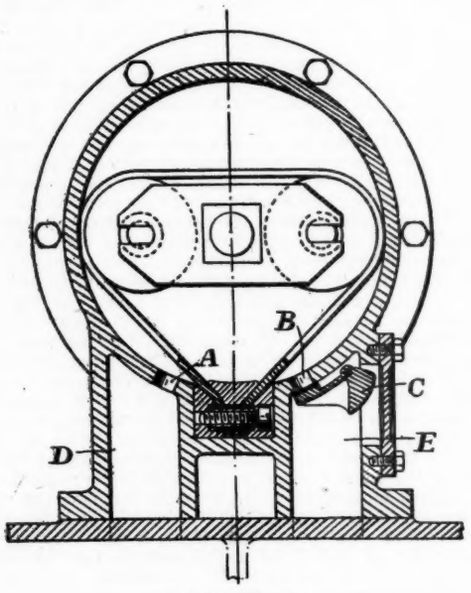
The section of the rod connected to the plunger may also be provided with a nut adapted to limit the stroke of the plunger by its abutment against the lower portion of the water-valve body, so that the volume of water obtained may be adjusted by changing the position of this nut.

Gas and Air Compressors or Blowers.—No. 179,324.

PALMER, J. F., of Wood Green, N. 22.

No. 4526; Feb. 8, 1921.

This invention relates to pumps of the type in which a rotatable member is arranged to roll-out progressively a chamber having a flexible wall, in order to expel the contents of the chamber. It consists in the combination with a casing of a flexible member formed from band material arranged as a loop, which, when pressed against the casing wall at one or more points by a rotatable member operating within the loop, forms one or more chambers between the loop and the wall of the cylinder, into which fluid may be admitted and passaged along the cylinder to a delivery outlet during the continued operation of the rotatable member.



Palmer's Blower.

The construction is clearly shown in the accompanying drawing, which is a vertical section through the blower. The cylinder is shown provided with inlet ports A and outlet ports B, the opening of the latter being controlled by a back-pressure valve C, which is pivoted on the cylinder casting. The cylinder is cast in one with supports, which provide ducts D and E which lead to the inlet and outlet ports respectively. The base of the support casting may be provided with openings leading to these ducts, when supply and delivery conduits are formed in the floor surface on which the pump or blower is to be arranged. Otherwise, there are provided for each duct main pipes for supplying and delivering the gas.

The drum of the cylinder is slotted longitudinally to receive the ends of the belt arranged within the cylinder to form a loop, which is free to be oscillated therein; packing pieces being disposed within the slot and held together by a transverse bolt member passing through a sleeve. It should be noted that the ends of the belt enter the slot in such a manner that as an axially rotatable member is moving, a smooth surface of a continuous nature is obtained. The packing piece is also dimensioned so that the radius from the centre of the cylinder to the inner face of the packing piece is equal to the reduced radius within the cylinder, when the loop is lying against the cylinder wall; so that as the axially rotatable member moves round, it passes from the loop,

over the packing piece, and again on to the loop without any jar or jumping.

The rollers being freely mounted, should any obstructions occur, they are given a small clearance in which to recede from the cylinder wall, while at the same time they can fly outwardly under centrifugal action to take-up the space which occurs when the loop has been used for any time. This is important, as, the loop (being preferably of leather and having in the course of working absorbed a quantity of oil) is easily compressible under the weight of the rollers.

Further details are then described in connection with the eight figured drawings included in the specification; and alternative constructions are explained, together with the cycle of operations. The patentee then points out that the apparatus is of the simplest possible character, and forms an effective pump or blower with no liability to leakage except between the sides of the loop and the covers of the cylinder. In place of leather as the material of the loop, a thin steel band of suitable material might be used.

To provide a substantially air-tight joint between the sides of the loop and the ends of the cylinder, a jointing edge of double material may be formed on the loop, or a metallic edge may be provided, which may be either continuous or divided into separate sections. Advantageously the cylinder walls may be recessed to allow of the material of the loop being rolled level with the cylinder wall over which the axial member and rollers revolve; the revolving member in that case being wider than the loop which forms the intermediate layer over the working surface of the cylinder. Larger volumes can then be conveniently dealt with by supporting a number of separate cylinders end to end and operating the internal mechanism by a single spindle passing through all the cylinders.

Measuring Calorific Value.—No. 179,060.

IGRANIC ELECTRIC COMPANY, LTD, of Queen Victoria Street, E.C. A communication from the Cutler-Hammer Manufacturing Company, of Milwaukee.

No. 10,302; April 7, 1921.

This invention relates to a method and apparatus particularly applicable to measurements of the calorific value of combustible gases or other chemically reactive agents, though certain features thereof have other advantageous applications. In a prior patent, No. 153,817, are disclosed a method and apparatus wherein constant volumetric proportions of test gas, combustion air, and cooling air are delivered under like temperature, pressure, and saturation conditions to a device for effecting combustion of the gas and transfer of the heat so liberated to the cooling air, the consequent temperature rise of the latter being indicated, whereby any variation in heating value of the test gas causes a corresponding proportional change in the indicated temperature rise of such cooling air—the latter comprising a measure of the former.

The present invention has among its objects that of advantageously varying this procedure. A more specific object is to obviate the necessity of certain corrections of the results of the former method. Another object is to provide for a constant temperature rise of the cooling fluid, thereby minimizing variations in heat loss and facilitating correction or compensation therefor. It is also sought to make compensation for possible errors due to temperature variations tending to influence the results.

Pressure prevents our abstracting the major portion of this long specification, and points from the claims of the patentees are only given. These are—

The method of determining the heating value of a combustible fluid according to which a stream thereof is burned in heat exchanging relationship with a stream of cooling fluid, and the ratio of the rates of supply of the two streams, which maintains substantially at a certain constant the temperature change which the cooling fluid undergoes by association with the combustion of the combustible fluid, is utilized to afford a measure of the calorific value of the combustible fluid.

The said ratio is adapted to be varied automatically in response to variations in the heating value of the combustible fluid, to maintain constant the temperature change of the cooling fluid.

The stream of cooling fluid comprises both a stream of combustion supporting fluid in direct association with the stream of combustible fluid for supporting the combustion thereof and an additional stream of fluid in heat exchanging relation with the products of combustion of combustible fluid but not in direct association therewith.

The necessary apparatus, as described and illustrated.

Prepayment Mechanism.—No. 179,580.

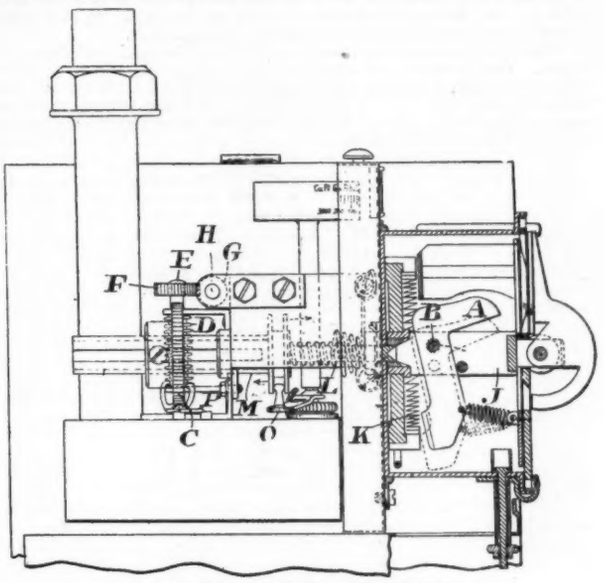
FOX, T., of Liverpool, and ROBINSON, S., of West Derby.

No. 5425; Feb. 17, 1921.

This invention relates to improvements in prepayment apparatus for gas-meters and the like, and to that type of device in which the coin is used to cause the connection between a pivoted lever and the quantity wheel. It has already been suggested to compensate for the varying diameter of coins in prepayment mechanism by means of making-up pieces, so that the combination of the diameter and making-up piece is constant, while the change in gearing has been effected by using a distance piece to displace gear wheels into predetermined positions.

According to this invention the pivoted lever can be fulcrumed in either of two different positions, and is adapted to be displaced to vary the distance between one end and the outer casing of the prepayment device according to the size of the coin to be used. Further, the alteration of gear ratio between the meter spindle and the gas-inlet valve is effected by a single displaceable pinion mounted on a sleeve actuating the valve and adapted to vary the gear train according to its position on the sleeve. The illustration is a side elevation, partly in section, of the prepayment device in position for shillings as the prepayment coin. The lever A is pivoted by the pin B, and the pinion C engages with the worm D mounted on a spindle E which carries a spur-wheel F meshing with a worm G. The worm G is connected to the spindle H by a removable pin.

On the insertion of the coin and the rotation of the handle, the spindle J rotates and the lever A engaging with the teeth K causes the rotation of the quantity wheel. The threaded spindle L on rotating causes longitudinal movement of a sleeve M, and a collar actuates a lever O to open the inlet valve. During consumption of the gas the



Fox's & Robinson's Prepayment Mechanism.

meter spindle rotates the spindle H, which by means of the worm G, spur-wheel F, worm D, and pinion C causes the longitudinal movement of the sleeve M in the opposite direction.

When it is desired to alter the meter to take pennies, the price-changing disc is removed by the removal of the coin receptacle and the unscrewing of the fixing device. The pin B is then removed and the lever A lowered into the dotted position shown. To change the gear ratio between the meter spindle and the threaded sleeve M, a lever P is provided which is pivoted and adapted to be moved into one of two positions. The movement of this lever causes its forked end, which engages the pinion C, to carry the latter into engagement with the worm G, thereby eliminating the spur-wheel F and worm D. This increases the gear ratio so that the valve O is operated twelve times as quickly as when shillings are used.

An alternative method of changing the gearing is specified, as are other details of the invention.

Prepayment Meters.—No. 179,589.

TAUNTON, R. P., and MCINDOE, R. W., both of Birmingham.

No. 1953; Jan. 13, 1921.

This invention refers to prepayment meters for gas and like fluids, and has for its object to provide improved means for altering and setting such meters for operating in accordance with the changes in price in the gas supplied; such means being operable by the hasp or the like employed for securing the money box used with such meters. The locking means for the price-changer are caused to move in or out of operative position by sliding or turning the locking hasp. Thus, when the price-changer is unlocked the hasp is out of register with the slot in the money till, thereby preventing its being pushed home and locked, and offering considerable advantages in use in that it eliminates any possibility of leaving inadvertently the price-changer unlocked or insecure.

The meters referred to are usually operated by a coin which acts as a clutch or connecting member between a handle part outside the meter and a means connected with a spindle forming part of the measuring mechanism and usually controlling the operation of a cut-off valve for the gas supplied through the meter, so that at each operation of the handle, when a coin has been inserted, the measuring mechanism may be racked back to a predetermined starting point.

Quantitative Detection of Carbon Dioxide and Combustible Gases containing Carbon.—No. 179,696.

THE VICTORIA FALLS AND TRANSVAAL POWER CO., LTD., and ANDREWS, W. O., both of Johannesburg.

No. 5654; Feb. 18, 1921.

This invention relates to the detection of the percentage of carbon dioxide, or of gases capable of producing carbon dioxide on combustion, in a mixture of gases. Many cases occur, the patentees point out, where the knowledge of the presence, absence, or percentage variation of carbon dioxide or combustible carbon gases is of great importance—for example, in atmospheric air in places such as submarines, mines, places of entertainment, and the like, or in furnace gases.

The first claim of the patentees must here suffice to indicate the general lines of the invention. This is—

A method of indicating continuously the percentage of carbon dioxide present in a mixture of gases, which consists in conducting the gases over or through a liquid, coloured indicator in a closed vessel under a definite pressure and utilizing the colour of the indicator as compared with standard tints to deduce the percentage of carbon dioxide present in the mixture; the indicator changing colour whenever the percentage of carbon dioxide present increases or decreases.

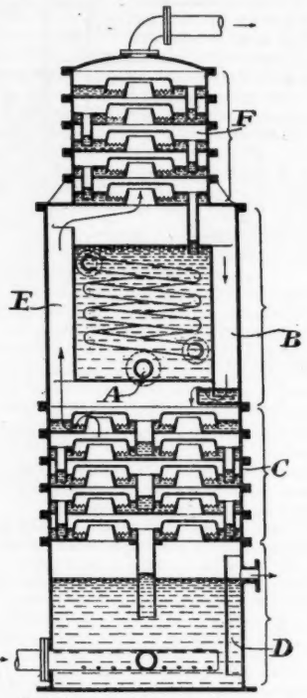
Distillation Columns.—No. 179,745.

STILL, C., and PETSCH, H., both of Recklinghausen.

No. 8150; March 15, 1921.

This invention relates to the construction of a column apparatus for continuously distilling the more volatile constituents of a liquid consisting of a mixture of components of high and low boiling point, and the object is to avoid a separate preheating apparatus.

The accompanying illustration is a vertical axial section of the apparatus. The lower part of the apparatus comprises a collecting vessel and, above this, the series of trays constituting the distillation column. Directly above this column there is constructed, as a feature of the invention, the heater for the liquid; this being closed at the top by the bottom of the rectifier column.



Petsch's Distillation Column.

The liquid mixture to be fractionated enters at A—a perforated pipe extending to the middle of the liquid container along its bottom; from this pipe the liquid rises to the upper edge of the overflow channel B and is heated to the necessary temperature by a coil fed, for instance, with steam. From the channel B, which has a liquid seal at its lower end, the heated liquid flows directly on to the topmost tray of the distillation column C, and thence from tray to tray through the respective overflows, until finally it flows through a dip-pipe into the collector D. At the bottom of the latter is a steam distributor for supplying the direct steam necessary for the distillation. Instead of this distributor there may be a closed steam-coil, in order by additional heating to produce distillation vapours from the liquid itself, which can be usefully done for many purposes.

The distilled vapours enter the space beneath the bottom of the heater, whence they pass through a channel E at the side of the heater, which channel extends higher than the level of the liquid in the heater and therefore higher than the upper edge of the channel B. The vapours now enter the space in the upper part of the heater, mix here with the small amount of vapours given off by the liquid in the heater, and enter the lowest tray of the rectifying column F up which they travel. They escape finally in finished condition to a condenser.

The condensate which flows down the column F from tray to tray through the overflows passes finally through a dip-pipe into the heating container, so that this condensate is subjected to further treatment together with the newly-entering liquid. The residual liquid, freed from volatile constituents, collects in the bottom part D of the column still, and is led away through an overflow.

The construction of the rising channel E, in such manner that the liquid from the heater cannot enter it, is essential to ensure smooth passage of the vapours and consequent regulated operation. For the same reason the overflow B is closed at the bottom by the liquid seal, for without such seal vapours would pass up the overflow B and check the downflowing liquid.

Attachment of Diaphragms—No. 179,783.

HILL, J., and IVERS, D., both of Birmingham.

No. 10,454; April 9, 1921.

The invention provides for the attachment of flexible diaphragms to gas measuring chambers or boxes of dry meters. It affects the clamping without the formation of holes in the flanges or in the material of the diaphragm by the use of a number of substantially built U-shaped small metal clips, each having as part of it a clamping screw pin. The clip simply screws up against the imperforate surface of the flanges, pulling the joint together gas-tight. A further feature is that the end of the clamping pin can conveniently engage a groove in the flange, so that there is no chance of the clip slipping off the flange. The use of the clip with the clamping screw pin is not, however, confined to flanges having a groove and bead engagement.

PARLIAMENTARY INTELLIGENCE.

STRETFORD AND DISTRICT GAS BOARD BILL.

HOUSE OF COMMONS COMMITTEE—Monday, June 19.

This Bill was considered by a Committee of the House of Commons on June 19, 20, and 21, under the chairmanship of Sir HARRY SAMUEL. It has already been passed by the House of Lords; the proceedings before the Committee in that case being reported at length in the "JOURNAL" for April 5 (p. 40).

Sir LYNDEN MACASSEY, K.C., the Hon. EVAN CHARTERIS, K.C., and Mr. F. N. KEEN appeared for the promoters. There were a large number of petitioners against the Bill, as was the case in the other House; and they were represented as follows: Manchester Ship Canal Company, by Mr. TYLDESLEY JONES, K.C., and Mr. WROTTESLEY; the Manchester Corporation, by Mr. HAROLD BEVERIDGE; and owners and occupiers of property and consumers of gas in the urban districts of Sale and Urmston, by Mr. ROWAND HARKER.

Sir LYNDEN MACASSEY, in opening for the promoters, proceeded on much the same lines as when the matter was before the House of Lords. The Bill, he explained, was promoted for the purpose of constituting a Joint Board, consisting of the urban districts of Stretford, Ashton-upon-Mersey, and Sale, and the rural disjricts of Barton-upon-Irwell and Bucklow, and to authorize that Board, when constituted, to acquire from the Corporation of Manchester the undertaking which recently belonged to the Stretford Gas Company, but which last year was acquired by the Manchester Corporation. The Bill was promoted under the circumstances detailed in clause 43 of the Manchester Corporation (General Powers) Act, 1921. A number of opponents asked that the present Bill should be rejected, and that they, as consumers and ratepayers, should remain under the Manchester Corporation, for the reason that they believed they would be better off. Counsel then went into the history of the acquisition of the Stretford Gas Company by the Manchester Corporation, and the alleged motives, as mentioned in the other House, for so doing. He then outlined the terms of purchase, and explained that at the meeting at Urmston, under the Borough Funds Act, the scheme was rejected; so that Urmston, although mentioned in the Manchester Corporation Act as one of the local authorities, was not one of the promoting authorities—there actually being five instead of six.

Mr. ROWAND HARKER, who appeared for gas consumers, &c., in Sale, said that the proposal had been rejected in Sale at the Borough Funds Act meeting, and yet Sale was appearing as one of the constituent authorities. This was a matter upon which he was going to ask the Committee to hear him later.

Sir LYNDEN MACASSEY then dealt with the price of gas in Manchester and Stretford, which was gone into in detail when the Bill was considered by the House of Lords Committee, as was the alleged propaganda by the Manchester Corporation as to the disadvantages that would accrue to the consumers of gas in Stretford if the sale took place. As regards the opposition of the Manchester Ship Canal Company, it was pointed out that the Manchester Corporation controlled the Canal Company, inasmuch as they appointed 11 Directors out of 21, and that the Chairman of the Gas Committee (Alderman Sir W. Kay) was Deputy Chairman of the Canal Company. The opposition of the Canal Company was as ratepayers.

Mr. TYLDESLEY JONES said the Canal Company paid 3 p.ct. of the rates of the district; and as the promoters had given a pledge to the ratepayers in the district that they would not charge more for gas than they did in Manchester, it was evident that it could not be done without a deficiency. As large ratepayers the Company objected.

The CHAIRMAN said he did not think a pledge had been given. It had only been stated that the Joint Board could supply as cheaply as Manchester. That was in the documents.

Sir LYNDEN MACASSEY said that in the last House certain of the opponents made a strong effort to induce the Committee to put a clause in the Bill that the price charged should not be higher than at Manchester; but the promotors objected to any such clause being put upon them, as it would tie them to Manchester, who could ruin the undertaking by reducing their price so low as to prevent the Joint Board supplying at an economic level. The other House refused to put in the clause.

Mr. TYLDESLEY JONES said his Company were not large consumers of gas, and were much more concerned that a price should be charged which would not permit of a deficiency being made.

Mr. ROWAND HARKER, explaining his position, as Counsel for gas consumers, ratepayers, and occupiers in Sale and Urmston, said that the former were not represented in the House of Lords. As far as Sale was concerned, he asked the Committee not to take cognizance of the petition in favour of the Bill, because the ratepayers had voted adversely to the scheme under the Borough Funds Act, and the Urban District Council could not override that decision by continuing to act as one of the promotors. Otherwise, all the protection to the ratepayers of the Borough Fund Act went. His evidence would show that the burden of a deficiency rate upon the ratepayers of Sale might be very serious. As to Urmston, his case was that, as a pledge or undertaking had been given, in the circulars issued on behalf of the proposed Joint Board, that gas would be supplied as cheaply as in Manchester, a clause to this effect should be inserted in the Bill.

Mr. *William Cash*, for the promoters, said that he had examined the terms of purchase, and regarded them as reasonable. From the figures of the engineers he had no doubt they could sell gas cheaper than 5s. per 1000 c.ft. The sum required by the Joint Board would be £340,000, to which was added £30,000 for extensions and working capital; making the £370,000 asked for in the other House.

Mr. TYLDESLEY JONES, for the Manchester Ship Canal Company did not cross-examine.

Mr. ROWAND HARKER, for the other opponents, put it that Sale would have to pay 25 p.ct. of any deficiency on the proposed Joint Board's undertaking. Witness would not agree to the deficiency

clause being taken out of the Bill, because, although there was a maximum price in it, there must also be provision against a deficiency. The maximum price was 5s. per 1000 c.ft.

Answering Mr. TYLDESLEY JONES, who put a question arising out of Mr. Harker's remarks, suggested the Joint Board should be compelled to levy a price which would cover expenditure, as was often done in the case of electricity.

Witness said he did not remember it having been done in the case of gas, but he had no objection in principle.

In re-examination, witness said he had satisfied himself that a maximum of 5s. would be enough to enable the Joint Board to avoid a deficiency. He did not think it fair that the undertaking should be compelled to pay the same price as another undertaking, such as Manchester, which was in a very different position; the output being 500,000,000 c.ft., as against 6,000,000,000 c.ft. in Manchester.

There was considerable discussion between the Chairman and Counsel as to whether a statement in circulars that the Joint Board could supply as cheaply as Manchester could be construed as a pledge that they would charge the same price as Manchester. Mr. Tyldesley Jones argued that the phrasing of the circulars bore that construction; but all he asked was that the Joint Board should be compelled to make both ends meet.

Mr. *W. M. Carr* then gave engineering evidence on the lines of that given in the House of Lords, already reported. His original estimate of the working costs for 1922 was 43·15d. per 1000 c.ft.; but he had revised this on the basis of that day's prices, and arrived at the figure of 42·65d., as against a maximum price of 60d. Items of economy in the future were the construction of a siding for which land had been purchased, which would effect a saving of 3¾d. per 1000 c.ft.; a further sum of 3d. per 1000 c.ft. could be saved by careful reorganization and adjustment in the method of operation and management; and, finally, if a sulphate of ammonia plant was erected, a further saving of 1d. per 1000 c.ft. could be effected. This total economy of 7¾d. would reduce his estimated costs of operation in 1922 to 34·9d.

Tuesday, June 20.

Witness, in cross-examination by Mr. TYLDESLEY JONES as to the alleged pledge by the promoters to supply gas as cheaply as Manchester, said that he saw no reason why the Joint Board should not supply as cheaply as Manchester, if Manchester did not drop its price below an economical limit.

Mr. TYLDESLEY JONES said if that was the intention—that the Joint Board would not go below an economic price—then he was at one with witness. At the same time, he did not believe it would be possible to supply in the area of the Joint Board at the figure suggested by the witness. His advisers suggested that the figure would be 48d.; and then if the same price was charged as charged in Manchester, there would be a deficiency. He wanted the Joint Board to be compelled to charge what the gas cost. He asked the Committee to put in a clause which would prevent the Joint Board from lowering the price so that the undertaking had to come on the rates.

The CHAIRMAN said the Committee were unanimously of opinion that there was no pledge that gas should be supplied in the area of the Joint Board as cheaply as in Manchester. At the same time, they regarded the case of the Manchester Ship Canal Company as a perfectly sound one.

Mr. ROWAND HARKER, as a result of this, said he would not put certain questions he intended to as to the alleged pledge, and Urmston would take no further part in the proceedings.

During the course of the re-examination of Mr. Carr, the Chairman said the Committee had no desire to burden the ratepayers in any way; and it seemed to him that some form of words might be arrived at to meet the question of deficiency.

Mr. ROWAND HARKER said he should ask the Committee to eliminate Sale as a constituent authority, on the point he had raised as to the Borough Funds Act meeting, at which the proposal was rejected by the Sale ratepayers.

Sir LYNDEN MACASSEY, for the promoters, said it would be a very serious thing if the Committee created a precedent by imposing the Northumberland Clause in a Gas Bill. There was the Model Clause in the Bill by which the Joint Board had to budget every year as to the probable revenue and expenditure. Should there be a deficiency, then it must be met by the constituent authorities.

Mr. TYLDESLEY JONES said he did not suggest that the security of the rates should not be behind the undertaking; but it should be made compulsory that the Joint Board should adjust their revenue to meet the expenditure. That would absolutely meet him.

The CHAIRMAN, after further discussion, said the Committee had enough facts on this point to enable them to come to a decision. The issue on the point of deficiency was perfectly clear.

Sir LYNDEN MACASSEY said that after this intimation it was no use pressing further evidence upon the Committee.

The position with regard to Sale was then dealt with.

Mr. *R. J. M'Beath*, the Chairman of the Highways and Lighting Committee of the Sale Urban District Council, gave evidence that, as the result of a meeting under the Borough Funds Act, a small majority voted in favour of the Bill; but when a poll was taken, the majority against was 216. The Sale Council then passed a resolution withdrawing from the promotion, but reversed that decision subsequently because a petition signed by 69 p.ct. of the electors was presented urging the Council to take part in the promotion.

Mr. ROWAND HARKER, in his cross-examination, suggested that the petition was got up mainly by people who lived in Sale and had business in Manchester, and who preferred Manchester to Sale.

Some local evidence was then called in favour of the Sale Urban District Council taking part in the promotion.

Sir LYNDEN MACASSEY, on the question as to the position of Sale remaining a party to the promotion after the ratepayers had rejected the proposal at a Borough Funds meeting, quoted precedents where Parliament had included local authorities in joint schemes in similar circumstances. None of these, however, were Gas Bills.

Mr. ROWAND HARKER argued that as the ratepayers had rejected the scheme at the Borough Funds Act meeting, the Urban District Council could not remain a party to the promotion, any more than the Urmston Urban District Council, who had withdrawn in similar circumstances.

The COMMITTEE agreed that, on the question of law, Sale could not be included; but on the question of merit, did Mr. Harker wish to be heard?

Sir LYNDEN MACASSEY said he took it that what the Committee meant was that there was nothing in the Borough Funds Acts of 1872 and 1903 to preclude the inclusion of Sale in the promotion, if the Committee thought fit.

The CHAIRMAN: You have the power of interpretation I have usually credited you with.

Mr. HARKER said he thought he saw what the position was; and he did not propose to say anything further.

Mr. TYLDESLEY JONES then addressed the Committee on the lines of his previous statements for the Manchester Ship Canal Company. He asked that a clause on the lines of one recently included in the scheme of the Mersey and West Lancashire district, decided upon by the Electricity Commissioners, should be adopted in the present Bill. This provided that the price of electrical energy charged by the Joint Authority under the scheme should be regulated, subject to the consent of the Commissioners, with a view to securing that the receipts therefrom would meet the liabilities on revenue account and provide a reserve fund for depreciation and renewal of plant.

The CHAIRMAN pointed out that the case for the other side was that such a clause would prevent money being raised.

Mr. TYLDESLEY JONES said that this clause had been accepted by the financiers in the electricity scheme he had referred to.

Sir LYNDEN MACASSEY intimated that he did not oppose the principle involved; but he said there was no reason for putting this Joint Board in any different position from other gas and water joint boards. He offered to meet the opposition by inserting the following clause: "If the maximum price per therm fixed by the Board of Trade under section 43 of this Act shall for any reason be insufficient to enable the Board to meet the charge first to sixthly described in section 80 (Application of Revenue) of this Act, the Board shall apply to the Board of Trade under the Gas Regulation Act, 1920, for an Order increasing such price."

Mr. TYLDESLEY JONES said that did not help him to put up the maximum, because it did not prevent the Board supplying at an uneconomic price.

The CHAIRMAN said this difficulty would never have arisen if Manchester had not bought the Stretford Gas Company's undertaking first; and he had grave doubts in his own mind whether they ought to impose the condition asked for by Mr. Tyldesley Jones.

Evidence was then called on behalf of the Manchester Corporation, the Chairman having stated that the Committee wanted the position made clear, although Manchester was debarred from opposing on preamble.

Sir *William Kay*, Deputy Lord Mayor of the City of Manchester, and Chairman of the Gas Committee, was called, and said the only object of the Corporation in publishing certain circulars in connection with this matter was to put the facts before the ratepayers and gas consumers in the districts concerned; these people then being constituents of the Corporation, and might become constituents of the Joint Board if the scheme went through.

The CHAIRMAN, after consultation, announced that the Committee were unanimously of the opinion that the preamble of the Bill was proved subject to a clause being settled by Counsel to prevent the retention of the price of gas charged to the consumers at too low a figure, thus causing a deficiency. The Committee deeply regretted the action of the Manchester Corporation, through the Chairman of the Gas Committee, in indirectly opposing the Bill in contravention of clause 43 of the Manchester Corporation (General Powers) Act, 1921.

Wednesday, June 21.

Sir LYNDEN MACASSEY, for the promoters, brought up the following clause to meet the Committee's decision as to preventing making a loss:

> "If in respect of any financial year the revenue from the undertaking is insufficient to meet the expenditure thereof, and the deficiency caused thereby is not made good out of the reserve or other funds of the Board, the Board shall so arrange the prices to be charged for gas in the next ensuing year as to secure as far as practicable that the revenue from the undertaking will, according to the best estimate the Board are able to make, be sufficient to prevent the continuance of such deficiency."

It was impossible, said Counsel, to put in a clause which would ensure that in all circumstances revenue would exactly cover expenditure, because there were such things as coal strikes and other unusual occurrences which could not be guarded against in a matter of this sort. Clause 81 would remain in the Bill as it was, and dealt with the apportionment of the deficiency (should one arise) between the constituent authorities, with the additional clause he had proposed.

Mr. TYLDESLEY JONES contended that the proposed clause did not give effect to the decision of the Committee, and he suggested a modification of Clause 81 to avoid the position which he said now arose—viz., that the new clause with regard to a deficiency did not come into operation unless there was a deficiency. What he wanted was to prevent a deficiency arising at all, if it could possibly be avoided. Clause 81 said that the Board should, before the commencement of every financial year or half year, as they might determine, "or so soon thereafter as may be practicable," cause an estimate to be made of the probable revenue and expenditure. He wanted those words taken out, and words added to make it clear that the Board should make an estimate before the commencement of every financial year or half year, and charge during every such period a price for gas which would ensure that the net revenue of the Board should not be less than the amount of the expenditure, other than capital expenditure, to be incurred by the Board during that year or half year. If, in spite of this, there was a deficiency, then the portion of Clause 81 which dealt with the apportionment would come into operation. He contended that this matter

must be dealt with under Clause 81, and not in the form of a new clause as suggested.

The Committee, after deliberation, dealt with the position in the form of the amendments to Clause 81 proposed by Mr. Tyldesley Jones. They accepted the words in the clause as originally drafted "or so soon thereafter as may be reasonably practicable," the deletion of which was asked for by Mr. Tyldesley Jones, but accepted the amendment that gas should be charged for at a price which should meet the expenditure (as asked for by Mr. Tyldesley Jones) according to the best estimate of the Board.

On the proposal of Mr. TYLDESLEY JONES, a new clause was added compelling the Board to go to the Board of Trade for a new maximum price higher than the existing 5s., should this prove to be insufficient to enable the expenditure to be met.

APPLICATIONS FOR PATENTS.

[Extracted from the "Official Journal" for June 21.]

Nos. 16,189 to 16,827.

AIRD, K.—"Gas cooking stoves." No. 16,253.
AKT.-GES. BROWN, BOVERI, ET CIE.—"Regulating transport of loose materials by means of gaseous mediums." No. 16,503.
BROWN, H. L.—"Retorting shale oil." No. 16,524.
BROWNE, F.—"Carbonization and distillation of coal, &c." No. 16,816.
CHESTERMAN, E. S.—"Gas-lighter." No. 16,710.
ELLIS, T. W.—"Treatment of tar, &c." No. 16,704.
ELLISON, W. T.—"Gas-mixing and gauge apparatus for gassing-frames." No. 16,769.
GLAZEBROOK, C. H.—See Chesterman, E. S. No. 16,710.
GOSKAR, T. A.—See Ellis, T. W. No. 16,704.
HAGGART, E. C. C.—"Oven and circulating water-heater." No. 16,616.
HAGGART, E. C. C.—"Gas-burner." No. 16,617
HAGGART, E. C. C.—"Gas-heater." No. 16,618.
JONES, H. S.—"Apparatus for automatically cutting-off gas or electric supplies at a given time." No 16,668.
KISSOCK, W. H.—See Ellis, T. W. No. 16,704.
LYNES, W.—"Ball joints for pipes." No. 16,438.
ROSSER & RUSSELL, LTD.—"Hot-water circulating boilers." No. 16,620.
SANDY, W. J. L.—"Apparatus for detecting presence of inflammable, &c., gases." No. 16,231.
SMITH, F.—"Pipe connections for gas meters, &c." No. 16,190.
SOC DES VERRERIES DE FOLEMBRAY.—"Gas-heated annealing tunnels, &c." No. 16,708.
TOOLEY, C. P. & G. W.—"Retorts for distillation of coal, &c." No. 16,621.
TREFOIS, L.—"Automatic means for regulating blast of gas producers." No. 16,808.
TURQUAND, F. J.—See Sandy, W. J. L. No. 16,231.
UNDERFEED STOKER COMPANY, LTD.—"Burning of fuel." No. 16,630.
VIVIAN, A. W. H.—See Ellis, T. W. No. 16,704.
WOOD, W. R.—"Mechanical stokers." No. 16,631.

A Coal-Tar Pitch Contract.

A dispute relating to the sale of a quantity of pitch was heard on Thursday last in the King's Bench Division of the High Court, held before Mr. Justice Bray. Plaintiffs were the Sun Fuel Company, Ltd., and the defendants were Messrs. Rudge, Brown, & Co. The contract in question was for the sale of 60,000 tons of medium soft coal-tar pitch. Mr. Bevington Ward, K.C. (for plaintiffs), said the question for decision in the case was merely one of damages. Sir M. Macnaghten, K.C. (for defendants), agreed. Mr. Ward said the contract was dated April 13, 1920, by which defendants agreed to sell and deliver to the plaintiffs this quantity of pitch. The price was to be 155s. per ton. Defendants dispatched 815 tons. Of that quantity, plaintiffs took delivery of 441 tons and used it, although they at first tried to reject it, as it was not up to sample. The material so accepted was not worth 155s. per ton, but something considerably less; and the difference in connection with that to which plaintiffs were entitled was £1529. There was also a claim by plaintiffs in respect of the defendants' failure to deliver the balance of the material. Evidence was called by the plaintiffs to the effect that the material supplied was blast-furnace pitch—an article much inferior in quality. After an adjournment, Mr. Ward said he and his learned friend on the other side agreed between them the question of damages in connection with the undelivered balance of the contract; the only matter now open between them. Sir M. Macnaghten said Mr. Ward had met him very fairly. Mr. Ward said there would be judgment for the plaintiffs for the sum in question, which he need not mention, with costs. His lordship assented.

The International Foundry Trades Exhibition at Birmingham Hall, Birmingham (the first of its kind in Europe), came to an end on Saturday. Eighty-five firms, manufacturing appliances and materials for foundry work, were represented, and approximately 1000 tons of machinery was installed. The Birmingham Gas Department displayed examples of modern apparatus for testing the strengths of foundry metals, as well as types of furnaces using town gas as a fuel for melting and annealing, core-drying, and other metallurgical purposes, and illustrations of pyrometry and other methods of temperature measuring. This Research Department (at the head of which is Dr. Walter) is doing an excellent work in the development of gas-heating apparatus.

MISCELLANEOUS NEWS.

GAS REGULATION ACT APPLICATIONS.

The following further notices have appeared in the "London Gazette" regarding applications to the Board of Trade for Orders under the Gas Regulation Act.

Borough of Walsall.

The maximum price now authorized in respect of the supply of gas by the undertakers is 4s. per 1000 c.ft.; and the price they have asked the Board of Trade to substitute for this is 1s. 3d. per therm.

Leicester Corporation.

The Corporation have applied for an Order providing for the charges for gas supplied at prices per therm, and to vary, alter, increase, or reduce such prices from time to time as they may think fit. They are not seeking power to alter the prices, but only to substitute a fresh method of charging for the gas supplied. The price per therm will correspond with the price per 1000 c.ft. as at present charged.

ALTERATION OF DECLARED CALORIFIC VALUE.

Southgate and District Gas Company.—The Company give notice that as from Sept. 24 next they will supply gas of a calorific value of 475 B.Th.U.

DECLARATIONS OF CALORIFIC POWER.

Chester-le-Street Gas Company.—500 B.Th.U. (April 29.)
Cranleigh Gas and Coke Company.—500 B.Th.U. (July 1.)
Drighlington and Gildersome Gas Light Company.—500 B.Th.U. (Sept. 25.)
Elstree and Boreham Wood Gas Company.—460 B.Th.U. (June 24.)
Neath Corporation.—425 B.Th.U. (June 30.)
Paignton Gas Company.—500 B.Th.U. (June 30.)
Rochdale Corporation.—475 B.Th.U. (Sept. 18.)
Rugeley Gas Company.—475 B.Th.U. (July 1.)

GAS REGULATION ACT ORDERS.

We have received from the Director of Gas Administration copies of the following further Orders made by the Board of Trade under section 1 of the Gas Regulation Act.

Tonbridge Gas Company.

After the declared date, (*i*) the standard price in respect of gas supplied by the undertakers shall be 14·2d. per therm; and (*ii*) the price of 13·6d. per therm shall be substituted for the price of 3s. 6d. per 1000 c.ft. wherever it occurs in section 36 (fixing price of gas with sliding-scale as to dividend) of the Tonbridge Gas Order, 1890.

For the purpose of ascertaining the authorized rate of dividend, any price charged per 1000 c.ft. before the declared date shall be rendered into the equivalent price per therm by dividing it by four.

After the declared date, the word "therm" shall be substituted for "1000 c.ft." where first occurring in section 30 (price of gas within the extended limits of supply) of the Tonbridge Gas Order, 1899, and in section 30 (price of gas within additional limits of supply) of the Tonbridge Gas Order, 1917; and the words "1 8d. per therm" shall be substituted for "9d. per 1000 c.ft.," and "16d. per therm" for "4s. 6d. per 1000 c.ft." where they occur in those sections.

After the declared date, the words "1·2d. per therm" shall be substituted for "6d. per 1000 c.ft," and "0·6 of a penny per therm" for "3d. per 1000 c.ft." in section 31 (price of gas supplied to the Urban District Council of Tonbridge) of the Tonbridge Gas Order, 1899.

Prepayment meter clauses are included. (June 21.)

Langley Mill and Heanor Gas Light and Coke Company, Ltd.

After the declared date, the standard price in respect of gas supplied by the undertakers shall be 15 8d. per therm.

For the purpose of ascertaining the authorized rate of dividend, any price charged per 1000 c.ft. before the declared date shall be rendered into the equivalent price per therm by dividing it by four-and-three-fifths. (June 20.)

GAS-METER (FEES) ORDER, 1922.

An Order has been made by the Board of Trade, and came into operation on the 2nd inst., under section 11 of the Gas Regulation Act, 1920, in regard to gas-meter fees. The Order states that the fees for the examination, comparison, and testing, with or without stamping, of meters, shall be as stated in the schedule, and that they shall apply equally in the case of meters tested *in situ*. The Order of the Board dated Nov. 3, 1920, is revoked.

Schedule.

	s.	d.
For all meters with a measuring capacity up to 50 c.ft. per hour (as indicated on the meter by the maker). .	1	0
For each additional 100 c.ft. or part thereof—		
In the case of a dry meter	0	6
" " " wet "	0	9

For the year the gross profit of the Dunfermline Gas Department was £18,146. Receipts from residual products were lower considerably; but the revenue from the sale of gas showed an increase of £2825. The estimated output for the current year is 290 million c.ft.

TAXING IMPORTED GAS-MANTLES.

The Committee appointed under Part II. of the Safeguarding of Industries Act to inquire into a complaint by the Incandescent Mantle Manufacturers' Association resumed their sitting on Monday of last week, when evidence was heard on behalf of the opponents. The members of the Committee present were: Sir BERNARD MALLET (Chairman), Mr. J. A. AITON, Sir JOHN N. BARRAN, and Mr. ARTHUR PUGH. A report of the proceedings at the first sitting appeared in the "JOURNAL" for June 14, p. 639.

Mr. *George Hands* (of Messrs. G. Hands & Co.) was the first witness called. He said that during the war it had been impossible for him to do successful business in gas-mantles, owing to the inferiority of the quality of those of the English makers with whom he dealt. The standard mantles were the "C" upright and the universal inverted, which represented about 85 p.ct. of the total consumption of mantles in England and at least 90 p.ct. of the total imports from Germany. He had not bought any German mantles since the war at prices below convention prices—in fact, the majority of imports he had made had been above convention prices. Taking the declared value of the goods at the Customs was not an accurate system of arriving at the price at which the goods were imported, as in addition to the actual invoice value there was the cost of freight, &c., which amounted to at least 3s. per gross. The large bulk of mantles imported into England during 1921 were at 46s. 2½d.—the German Convention price. The average price at which he purchased mantles from Germany before the war was 20s. per gross for "C" uprights, and 26s. 6d. per gross for inverted. At that time there was very severe competition with English manufacturers, some of whom were undercutting the German prices considerably. In his view, the British Mantle Manufacturers' Association took advantage of the fact that there was no competition to impose a fancy price upon the article in question out of all proportion to the real cost of production. With regard to seconds, he considered a reasonable percentage of seconds was 7½ p.ct. In his experience, which extended over a large number of years, it had not been possible to obtain from the German manufacturers a larger proportion of seconds than would be allowed by the English manufacturers; and that was so at the present time. With reference to the alleged subterfuges and evasions of the German export laws, he was of opinion that such attempts, if indeed they were successful, were isolated occurrences, and that if any mantles had been imported under any of the so-called tricks, they represented a very small percentage of the imports. He was the proprietor of a trade mark called "White Light;" and there was no doubt that all his customers for those goods were aware that they were German made. With regard to the cost of manufacture of mantles in England, which it was stated by the complainants was 21s. 1d. per gross before the war and at present 52s. 9d., in his opinion the latter figure was grossly exaggerated. Before the war it was possible for gas undertakings to buy a well-made British mantle of the upright type for 25s. and the inverted type for 32s. per gross, and at the present time British mantles of these types could be purchased at as low as 36s. per gross. He was strongly of the view that, if proper purchases of materials were made and the factories were economically worked, English mantles could be produced at a price considerably below 52s. 9d. To arrive at what was the real cost of production in England, he submitted that it was sufficient to take a small factory which produced a good class of mantle and worked at a reasonable profit, and if the Committee took that course he was certain they would find that the supposed costs of the combine were far in excess of what was reasonable and economical. He was of opinion that the effect of the combine of the British Mantle Manufacturers' Association, which claimed to control 95 p.ct. of the output in England, had been to keep prices at a figure totally inconsistent with the true value of the article and with the cost of production.

In reply to the CHAIRMAN, witness said he thought the consumption of mantles was decreasing owing to the Daylight Saving Bill, the shorter hours of work, and the competition with electric light.

In reply to Mr. BARRAN, witness said that the British mantles at 36s. per gross were not a tempting proposition to him, because his experience of English mantles had not been satisfactory. He had never come across a British made mantle equal to the ones he imported from Germany.

Mr. *E. A. Wood* (proprietor of the firm of E. A. Wood, of Birmingham and Glasgow) was the next witness. His firm were big importers of various articles, and also did a large business in English made articles. He was also a manufacturer of clay rings used in the manufacture of gas-mantles. Before the war he was interested in an English factory, and had dealt in German made gas-mantles for many years. He thought the figures given by the English manufacturers for the cost of production before the war and at the present time—*i.e.*, 21s. 1d. per gross and 52s. 9d. per gross respectively—were much exaggerated and totally inaccurate. Before the war good English mantles could be purchased at from 12s. to 15s. per gross; and the makers were obtaining a reasonable profit on their outlay. At the present time, having regard to the cost of labour and materials, he was of opinion that the cost of production should not exceed 30s. per gross. In his view, the combine of the English mantle manufacturers resulted in keeping up the price to the consumer. During the war and shortly after it, with no competition, the English manufacturers produced a very inferior mantle at a price out of all proportion to its cost, and he had many complaints from people as to the inferiority of that mantle. He considered it essential in the interests of the industry that reasonable competition should be allowed. With regard to the price at which German mantles were imported into England, he had not sold mantles in England under the German Convention prices—*i.e.*, 46s. 2½d. per gross until March last, and since that date 34s. 6d. per gross. The figure of 35s. 1d. per gross put forward by Mr. Bruell as being the average price of mantles imported from Germany into this country in 1921 was entirely fallacious. In his view, the quantity of seconds supplied by the German makers was not in excess of that which British makers were prepared to supply—in fact, he had reason to believe that the British manufacturers would supply a proportion of seconds above the proportion which the German manufacturers would supply. In arriving at the cost of production in England at the present time, he considered it was not a proper method to take the costings of three of the largest factories of the combine, which were probably much over-capitalized and bore heavy overhead charges. He suggested that, if the Committee took a small well-equipped factory and dealt with the production on the basis of the present cost of production based on current rates of wages and actual costs of materials, they would find that the actual cost of production in England on an economical basis was probably 40 p.ct. below that which manufacturers claimed it to be. He was of opinion that the falling-off in the sales of mantles was not altogether due to the competition from Germany but was to a large extent explained by the fact that the total demand was considerably less, because electric light had replaced gas to a large extent during the last few years, and also because of the high cost of gas mantles, and the passing of the Daylight Saving Act. He was firmly of opinion that in the event of a 33⅓ p.ct. being placed on imported mantles infinitely more harm would be done to the community at large than the benefit that would ensue to a few individuals.

In reply to a question from the CHAIRMAN as to whether British mantles were inferior to German, witness said he obtained a very good mantle from one British maker. During the war business was disorganized, and there was a difficulty in obtaining materials. He did not think the British mantle was inferior to the German mantle now to the same extent as it was during the war.

In reply to Mr. BARRAN, witness said that in 1914 he paid about 21s. 6d. per gross for inverted mantles and 30s. to 33s. for the British article comparable with them; the higher price of the British mantle being due to the fact that it was a trade mark and the manufacturers could put their own price on it. He thought a cheap mantle ought to be produced to-day at a cost of 30s. and sold to him at 36s. a gross.

In reply to Mr. AITON, witness said he thought the British mantle manufacturers were short of work because their prices were too high. They were setting the price at the present moment on the assumption that there would be a 33⅓ p.ct. duty put on the importations.

Mr. *A. C. Eberhardt* (a Director of Messrs. Lotz, Abbott, & Co., Ltd.) said for many years before the war his firm imported German gas-mantles, of which they sold a considerable quantity; the price then being from 11s. 3d. per gross. Before the war, English mantles were sold at about the same price; and there was a good deal of competition. In his opinion, the pre-war German mantles were of better quality than some of the mantles made in England. During the war he had bought mantles from Holland at about 24s. per gross, free delivered. The great decrease in the prices quoted by his firm in 1922 for German mantles as compared with the prices quoted in 1921 was caused by the cutting of prices in this country by English manufacturers, for which he thought there was no necessity whatever. German manufacturers, in order not to be cut out of the market, had naturally to reduce their prices accordingly. He would inform the Committee confidentially of the average sales of his firm during 1921 and 1922. The bulk of the mantles imported by his firm had been sold to wholesale buyers at the Convention prices and some above. Mr. Bruell, in his evidence before the Committee, had stated that the average price at which German mantles were imported into England in 1921 was 35s. 1d. per gross, but that was arrived at by taking the total number of imports and averaging the cost accordingly. If certain factors were taken into consideration, it would be found that the Convention price of 46s. 2½d. had been adhered to; and possibly the average cost of the imports would amount to slightly more than the Convention price. With regard to the falling off in the sale of mantles, he attributed that to the Daylight Saving Act, to the present state of trade in England, to the fact that many factors were overstocked with mantles, and also to the decrease in gas lighting, particularly for outside shop lighting. In his view, the total demand for gas-mantles had declined.

Mr. *Thomas Harris* (Managing-Director of Messrs. Albert Lee & Co.) was then called. He said his firm carried on business as importers, distributors, and manufacturers of articles for the lighting trade, and also dealt with a considerable quantity of English made articles. Before the war, as Manager of the United Chemical Works, Ltd., he sold a considerable number of gas-mantles per annum. A fair average would be 40,000 gross per annum; and the average price was about 16s. per gross. The average price at which German mantles were sold in England before the war was 14s. per gross for upright and 20s. per gross for inverted. It was always a difficult matter to obtain orders, owing to the competition of certain British makers; there being very little difference between the prices of the English and those of the German mantles. From the experience he had gained when in the employment of Messrs. Falk, Stadelmann, & Co., he knew that the cost of production of mantles in England before the war did not amount to 21s. 1d. per gross; and he considered that a most extravagant figure. Since the war, and until late in 1921, his firm dealt exclusively with English-made mantles. He was prepared to give the Committee confidentially certain information as to the cost of production in England at the present time, which, in his view, would prove that the statement made by the British Mantle Manufacturers' Association that the present cost of production was 52s. 9d. per gross was incorrect and grossly exaggerated. He did not agree with the figures given by Mr. Bruell as the prices at which German mantles were imported into England. In his experience, there had been many offers of mantles throughout England from representatives of Polish and Austrian firms at very low prices; and he considered that if the various cheap lots about which evidence had been given were traced to their source, they would be found to be of Polish or Austrian origin. His firm and other importers had not imported mantles under the Convention price; and he stated that an abnormal quantity of seconds had not been imported. If the Committee investigated the Board of Trade returns and the declared values, they would find that the German Convention prices had been adhered to. With regard to the alleged cost of manufacture in England, he considered that to take the costings of the three largest factories was totally misleading. If the Committee would take the actual costings of the standard type of mantles and not the cost of a

higher quality high-pressure mantle and other large sized mantles, they would find that the present cost of production was considerably lower than the price claimed in the complaint of the British manufacturers. He would produce evidence of offers made by British manufacturers at prices considerably lower than 52s. 9d. With some of the smaller factories in England it was possible to obtain good quality goods at a very reasonable price; and he believed that those firms were making a reasonable profit on their products. In his view, the British Mantle Manufacturers' Association was established for the purpose of keeping up prices; and it had only been the reasonable competition which was brought about by importers of mantles that had brought the present price to a reasonable figure. The prices at which mantles could be sold in England by the English manufacturers would yield them a reasonable profit if their factories were properly and economically controlled and not over-capitalized and burdened with unnecessary overhead charges.

In reply to Mr. BARRAN, witness said he was free to purchase mantles where he liked at the present time, and he had had offers of British inverted mantles of a good standard quality at 39s.

Mr. *A. J. H. Shay* (of Messrs. Keens, Shay, Keens, & Co., incorporated accountants) was the last witness called. He said that complainants stated that foreign mantles had been sold during 1921 at certain average prices per gross; but, as an accountant, he would not accept such figures without making searching inquiries as to the materials upon which the particular averages had been compiled. In any case, the declared value of goods as furnished by the Customs was obviously under the price at which they were offered for sale in this country, and was not a reliable indication of the price. The value given to the Board of Customs was the price of the articles *ex* factory. To this figure would have to be added all the freight and handling charges between that point and the actual sale in this country. Taking into consideration the cost of freight, &c., the proportion of seconds, and the proportion of soft mantles, he considered the Convention price of 46s. 2½d. for 1921 had been substantially maintained, or probably a slightly higher figure. The complainants had to satisfy the Committee that similar goods to the imported article could only be profitably manufactured in the United Kingdom—the manufacture being carried on with reasonable efficiency and economy—at a figure above the sale price of the imported article; and for this purpose the figure they gave was clearly fallacious and unsound. An average figure taken for the manufacturing costs of several factories, where, owing to different conditions and possibly differences in management, some might have comparatively high manufacturing costs, was open to serious objection, as it was not the figure specified by the Act. The figure specified by the Act was the price at which similar goods could be profitably manufactured in the United Kingdom; the production being carried out with reasonable efficiency and economy. The Incandescent Mantle Manufacturers' Association made a great variety of qualities and sizes of mantles, some of which were sold at prices as high as 160s. per gross net; whereas the ordinary type of mantle was, according to the evidence of the importers, sold at 54s., subject to special discounts. Obviously averages taken for the whole of those varieties of mantles could not give any reliable indication of the manufacturing cost of the types of mantles which came into competition with the foreign imported article—*i.e.*, those known as standard types. The most satisfactory way to ascertain the cost at which standard mantles could be profitably made with reasonable efficiency and economy at the present time was to compare in detail manufacturing costs of the various mantles made by individual concerns engaged in the manufacture of mantles in this country. The fact that no profitable manufacture of gas-mantles was being carried on at the present time was undoubtedly mainly due to exceptional trade conditions. According to the complainants' own figures, the total sales of their mantles in the United Kingdom declined from 443,731 gross in 1920 to 275,931 gross in 1921—a decrease of 167,800 gross. The increase of German imports for 1921 over 1920 was 41,437 gross, or less than 25 p.ct. of the loss in sales suffered by the British manufacturers. It appeared that the average present cost of 52s. 9d. per gross given by the complainants was swelled out of all proportion by a tremendous percentage of oncost for overhead charges. He considered that the statement of the complainants that there was a normal demand for gas-mantles not affected by fluctuations to the same degree as other industries required to be received with great qualification, having regard to the actual difference between the sales in 1920 and 1921. He also considered that the relative figures of mantles exported by the British manufacturers should be given in detail. He exhibited a declaration by Mr. Richard Feuer, in which it was stated that the cost of production of gas-mantles in Holland in 1920, of the ordinary quality and type, was G.12 per 100. This equalled G.17 28 per gross, which, at a rate of exchange of G.11·50 to the pound, was equivalent to £1 10s. per gross. He was informed that the cost of production in the United States in 1920 for an ordinary type of mantle was $5 per 100—*i.e.*, $7·20 per gross—which, taken at a rate of exchange of $4·50 to the pound, equalled £1 12s. per gross. He also exhibited a copy of a declaration made by Dr. W. Saulman, of Berlin, stating that the pre-war average cost of production in Germany was 8·50 pfennigs per mantle, and that the present cost price was 8·50 marks per mantle, which showed an increase of exactly 100 times. The rate of exchange had lately been approximately 1250 marks to the pound, equalling 62½ times pre-war exchange; so that the Committee would see that, so far as the gas-mantle industry was concerned, the depreciation in the value of the mark was of no advantage in the cost of production, but in fact operated the other way, and that the cost of the manufacture of mantles in Germany to-day was proportionately greater than the depreciation in the value of the mark. He also exhibited a copy of the "Economist" for June 3, 1922, giving the index figures for Germany at the end of April, 1922, for manufactured goods, which showed that generally the cost had increased 65 times pre-war cost. The relative index figure for England was 167. The British manufacturers, however, claimed that the cost of production in England had risen from 21s. 1d. pre-war to a present cost of 52s. 9d. per gross, or an index figure of 250, against the general index figure of 167, which bore out the statement that, generally, the cost of the production of mantles had increased more than the average increase in manufactured articles. It was clear therefore that the cost of production of mantles in Germany was not assisted by the depreciation of the mark. He wished to point out to the Committee that the complainants stated that the capital invested in England in the gas-mantle industry was £1,500,000, and that the turn-over in 1920 was £1,359,267. If the total turn-over in a good year was less than the capital invested, it necessarily followed that the articles must be sold at a considerable profit to ensure an adequate return on the capital invested. In addition, the very large capital in relation to turn-over would seem to show that either the concerns were grossly over-capitalized or they failed to make adequate use of their undertakings.

Mr. AITON said it was generally accepted that the German rate of wages was infinitesimal compared with the rate in this country.

Witness said he thought everything depended upon the purchasing power of the wages in the respective countries.

Mr. AITON pointed out that the question was how much the mantle manufacturers had to pay for a certain amount of work. If one man paid 3d. in one country and another man paid 1s. in another country, the first had an advantage over the second, irrespective of what could be bought for the money. There was no information that the amount of service given by the Germans had depreciated at all; but the amount of remuneration in wages had depreciated owing to the depreciation of the mark.

Wednesday, June 21.

Herr *Heinrich Zeigler*, one of the Managing Directors of the Auerlicht Gesellschaft, of Berlin, said that his Company produced 45 p.ct. of the total gas-mantles manufactured in Germany, and before the war owned the Earlsfield works, and controlled the English Welsbach Company. He had been connected with the Auerlicht Gesellschaft for the past fourteen years and was a member of the Committee of the German Convention of Gas-Mantle Manufacturers' Association.

By the law of the German Republic, it was unlawful for gas-mantles to be exported to England without an export licence, and that licence was only granted upon certain terms, one of which was that the price at which the mantles were sold must be the price fixed by the Government and ruling at the time the licence was given.

The figures given by Mr. Bruell as the prices in Germany for mantles were not the prices ruling at the present time. The minimum prices for the most inferior qualities were from 9·10 marks to 11 marks, and an increase of 2 marks per mantle would probably be made by the Convention at the end of the present month. The export price to England had been fixed bearing in mind that the price must be above the cost of production of similar articles in England, so as to avoid the imposition of a duty under Part II of the Act, and also that the cost of production in Germany was rising so rapidly that within a short time there would be no difference between the English price and the German price; and, having regard to the very severe fluctuations in the value of the mark, it was unsafe to fix a lower price. With regard to the difference between the German prices and the English prices of mantles, he wished to draw attention to the fact that on all mantles exported to England the German manufacturers had to pay a duty of 6 p.ct. *plus* 2 p.ct. to the German Government, which amounted to about 2s. 6d. There was also the cost of the cases, freight and insurance, which amounted to about 3s. per gross; so that in arriving at the German price there must be added 4s. 6d. per gross over and above the actual cost of production before mantles could be delivered to England, which neutralized any advantage the German manufacturers might have over the English manufacturers in the rate of wages paid in the respective countries. With regard to the cost of production in England, witness said that his Company would be prepared to take over the Earlsfield works at a reasonable valuation, to guarantee to produce upright and inverted mantles of good quality for sale to the wholesale trade in England at 34s. per gross, and to employ none but English labour in the factory and materials bought in England. He was quite satisfied that this would leave a handsome profit for the manufacturer. With regard to the capital employed by the English manufacturers as compared with that employed by the German manufacturers, he produced a Declaration by Mr. W. Saulmann which stated that with a capital of 200,000 gold marks he produced 5 to 6½ million mantles per annum, or nearly three times the value of his capital. He brought to the notice of the Committee an offer made to the German Convention on behalf of the English manufacturers, who said that if the German manufacturers would undertake not to supply either directly or indirectly through any other country any mantles except to a central buying office to be formed by certain English makers, they would undertake, for a period of three years, to buy from the German Convention a quantity of six million mantles annually—a figure which was subsequently increased to ten millions.

In reply to a question by Mr. MOORE, witness said it was very difficult to say whether the addition of 33⅓ p ct. duty would prevent German manufacturers sending their mantles to England. Some firms might cease to do so, but others would have to continue because they had only English business.

Replying to a question by Mr. PUGH, witness said there had not been any important mechanical development in the manufacture of mantles during the last few years in Germany.

Mr. *S. S. Ogilvie*, Joint Manager of the National Gas Council of Great Britain and Ireland, was the next witness. He said the question of the Safeguarding of Industries Act had been considered on several occasions by the Central Executive Board of the Council; and it was decided as early as January, 1921, that the free import of such articles as gas-mantles and heat-resisting glass was essential to the industry. He sent out circulars on the subject to all the members of the Council in May, 1922, and had only received 20 replies in opposition to the policy of the Central Executive Board. The Council were strongly opposed to any duty being placed upon gas-mantles. It was of paramount importance to the gas industry that all costs in connection with gas lighting should be reduced to the minimum. It should be borne in mind that gas was used as an illuminant mainly by the working classes; and the Council felt most strongly that they should not be burdened with any additional costs in that respect. The increase in the price of mantles was worthy of note. In 1914, the price of a

high-class mantle of the inverted or universal type was 2·88d., and of the upright "C" type about 1·77d. The highest prices were reached in the first six months of 1920, when the price of the universal reached the figure of 5·63d. and of the "C" 5·41d. The prices ruling in May of the present year were 4·31d. and 4·49d. respectively, and at the present time 3·83d. and 3·65d. respectively. If it had not been for foreign competition, prices would not have fallen, and the industry would have been saddled with the high costs which were ruling during 1919 and the first six months of 1920. Unless the price of mantles could be reduced, there was no doubt that fewer burners would be used, and that business would be lost. It was estimated that there were to-day between 2500 and 3000 men engaged in mantle maintenance throughout the country. He submitted that no case had been made out for the imposition of a duty under Part II. of the Act.

Mr. *Bernhard Young* was the last witness called in support of the opposition's case. He said he was engaged by Messrs. Richard Feuer & Co., of Berlin, to superintend the building of their new factory at Earlsfield about 1906, and to equip it for the manufacture of gas-mantles; and he remained there as Manager of the factory until after the commencement of the war in 1914. He had prepared a statement showing the exact cost of manufacture of gas-mantles in England prior to the war, from which the Committee would see that the cost was 13s. 5½d. per gross for upright mantles and 15s. 3d. per gross for inverted mantles of the ordinary types. He had included in that statement a calculation showing at what cost mantles could be manufactured in England to-day In arriving at that cost he had taken the actual costs of materials in England at the present time, the actual cost in wages as shown by the complainants, and an increase on all overhead charges of 1¾ on pre-war cost, although the English index figure was 167. The figures at which he had arrived were 22s. 8½d. per gross for the upright mantles and 25s. 1¾d. per gross for the inverted mantles. With regard to the pre-war cost, the statement made by the complainants that part of the work of manufacture was done in Germany and a partially finished article sent to Earlsfield did not apply to the period on which his calculations were based.

Mr. SOPER, Counsel for the complainants, said he had analyzed the weekly returns received from the Customs for the period from April 1, 1921, to March 31, 1922; and he handed his analysis to the Committee. His figures showed that of the total imports during the year in question only about 30 p.ct. came in at Convention prices. He had taken 40s. instead of 46s. 2d. as the Convention price, to allow for freight, &c.

Mr. KENNETH SWAN, Counsel for the opponents, then addressed the Committee. He said that in the present case there were two British interests in conflict—the manufacturers, on the one hand, who would no doubt be very glad of a little protective duty to enable them to carry on their business more profitably, and, on the other hand, a body of importers of German mantles, who were importing into this country about 63,000 gross of mantles per year—a figure which should be borne in mind in considering the total sales, which in 1921 amounted to 275,000 gross. The importers were attempting to recover a business which they had lost during the war, and which before the war was a very considerable one; and now they were threatened with a duty which, if it would not entirely destroy the importation, would at any rate very seriously handicap it and very seriously injure the business and livelihood of the importers and the considerable staff of travellers employed in the importation. He submitted that political considerations and questions as to whether foreign labourers should be employed to do work that English labourers could do did not legitimately enter into the Committee's consideration of the question. If the complainants' case was to be accepted by the Committee, the Committee would have to find first that the import price was below the manufacturing cost, and incidentally would have to be satisfied that the manufacturing cost was the cost of manufacturing the goods with reasonable efficiency and economy. If the Committee found that the import price was below the manufacturing cost and was cutting out the British manufacturer, they also had to be satisfied that this state of affairs arose from the depreciation of the mark. Even if those conditions were fulfilled, the Committee also had to be satisfied, before they recommended that a duty should be imposed, that the importation of German mantles was so serious a matter and on such a large scale that it seriously affected the employment in any industry in the United Kingdom. In regard to costs, the complainants had put forward two figures—52s. 9d. as the present cost and 21s. 1d. as the pre-war cost. He submitted that the figure of 52s. 9d. was *prima facie* suspect because it was an average figure. What the Committee should take was the most economical manufacture and not the most economical manufacture averaged over three companies. Mr. Harris in his evidence said he had been offered standard mantles at from 36s. to 40s. a gross, and made it clear that the mantles were of good quality. Mr. Young had given figures showing the actual cost of manufacture of a standard mantle at Earlsfield in 1914, figures which, he submitted, very seriously discredited the figure of 21s. 1d. put forward by the complainants as the cost of manufacture prior to the war; and therefore indirectly discredited also the figure of 52s. 9d. Mr. Roberts, who had given evidence on behalf of the complainants, stated that he had sold a mantle, the "John Bull" mantle, at 10s. 6d. a gross prior to the war; and Mr. Eberhart gave evidence that he had bought a standard mantle at 15s. or 16s. a gross before the war. It was a matter of considerable difficulty to arrive at the true lowest manufacturing cost; but the Committee had to arrive at some figure, and he submitted that the figure of 52s. 9d. could not be accepted as even approximate to the true manufacturing cost. If the Committee accepted his submission, based upon the evidence, that the true manufacturing cost was in the neighbourhood of 23s., 24s., or 25s., then it was perfectly clear that mantles had not been imported into this country at a price below that manufacturing cost. If, however, the Committee accepted the figure of 52s. 9d., then mantles had come into this country at a cost which was less than the manufacturing cost; and the Committee had to inquire whether that underselling by the Germans was due to the depreciation of the mark. If, however, the Committee found that the import price was below the manufacturing cost, and that it was due to the depreciation of the mark, the next point to be considered was whether the importation of German mantles was of such a character as seriously to affect employment in this country. The National Gas Council, which could not be charged with any interested motive in the matter, had come forward to represent the view of the gas companies in this country, which was that competition was desirable, and that the result of the imposition of a duty would be the raising of prices. They feared it would put it into the power of the combine to raise the price of mantles so that the number of gas-mantles sold would decrease and the general business of gas undertakings would be affected. He submitted, on the grounds he had stated, that no case had been made out by the complainants.

Mr. SOPER then addressed the Committee on behalf of the complainants. He said he accepted Mr. Swan's suggestion that the first point the Committee had to consider was whether mantles were being imported from Germany at prices below the British cost of production. To find out whether that was so or not, the Committee must first satisfy themselves as to what were the costs of profitable production and at what prices mantles were being imported. With regard to the cost of production, the Committee had before them certified copies of the costs of production of three or four of the complainants' factories, taken at different times and under various conditions; and in their estimates of present-day production, the complainants had differentiated between their total overhead charges and the charges which might be attributable to small quantity distribution and selling. He submitted that those figures substantially bore out the figures which the complainants had made the basis of their case. He then dealt with the various grounds upon which the opponents discredited the complainants' figures, one of which, he said, was a statement made by Mr. Harris as to the price of certain mantles offered to him. One of the Companies in question was the Pilot Mantle Company, whose works were now closed, so that obviously that Company had not carried on its manufacture at a profit. Another test applied by the opponents to the complainants' figures was the table of comparative costs put in by Mr. Young; but the complainants did not agree with the present prices of materials as given by Mr. Young, and had put in present prices that would enable the Committee to check and at once falsify a substantial part of Mr. Young's figures. Again, the Earlsfield factory, with which Mr. Young had dealt, was a factory working without any distribution charges and therefore with comparatively few of the overhead charges which other factories engaged in the business had to meet. With regard to the question whether the prices at which German manufacturers were able to import mantles were due to the depreciated currency in Germany, he produced the most recent report issued by the Department of Overseas Trade on the economic and financial conditions in Germany, made by the Commercial Secretary to H.M. Embassy, Berlin, in which it was stated that there could be no doubt that Germany had been able to attract to herself a large part of the world's trade in manufactured goods owing to the low rate of the mark, and that in a time of general depression such as the present that was a boon of almost incalculable advantage. He submitted that the principal cause for the falling off in orders experienced by the British manufacturers was due to German importations. The English manufacturers employed the same machinery and adopted the same methods of manufacture as the Germans, with such improvements as they were able to devise from time to time. Mr. Ogilvie had referred in his evidence to the price of mantles before the war and the highest figure reached after the war, and said that in 1914 the price of an inverted mantle was 2·88d., as compared with 5·63d. in the first six months of 1920—a rise of 100 p.ct. The Committee had heard of the rise in the cost of raw materials and how the gas-mantle industry was dislocated during the war. He strongly pressed upon the Committee that if British manufacturers had not carried on their industry with the greatest efficiency and economy, they would have been totally unable to meet the conditions they had to meet during the war, and that, using materials at the prices they had to pay during the war, they would have been absolutely unable to keep the price of their mantles down if their manufacture had not been both efficient and economical.

The inquiry then closed.

MALTA AND MEDITERRANEAN GAS COMPANY, LTD.

The Ordinary General Meeting of the Company was held on Tuesday of last week, at the London Offices, Nos. 59-60, Gracechurch Street, E.C.—Mr. A. F. PHILLIPS (the Chairman) presiding.

The SECRETARY (Mr. C. J. Daun) read the notice convening the meeting, and the certificate of the Auditors; and the Directors' report and the statement of accounts were taken as read.

The CHAIRMAN said that, at the general meeting last year, he had to explain the difficulties the Company had to contend with in their business in Sicily, and the loss they had sustained since the war because the Italian Government would not allow the price of gas to be raised to meet the great increase in the cost of coal and labour. The Company had been freed from the Marsala business; but the loss on the Trapani station continued, and for that year was £3433. The Directors had, however, just then received information that the Central Commission in Rome had granted the rescission of the contract, subject to the Company continuing the supply of gas for a further three months. Though this represented a loss, the Directors accepted it with satisfaction, because it terminated the serious losses the Company were incurring in Sicily. They carried out the conditions, and handed over the works to the town on Oct. 1, 1921. The Trapani works stood in the Company's books at £20,214, which sum had been written-off the amortization account. Compensation had to be given to those employed, and many other expenses met.

THE ITALIAN GOVERNMENT AND COMPENSATION.

The Italian Government had not settled the claims of the Italian gas undertakings under the "Pareggio" by which the gas companies were to be compensated for any loss sustained during the war in continuing the supply of gas at prices fixed by the Government. He feared there

was small prospect of obtaining this compensation. All who were connected with the gas business in Italy were aware of the enormous losses that had been sustained, and how the shareholders who found the capital had gone for years without a dividend, because it was not permitted to increase the price of the gas to make its supply remunerative; and when the price was increased, it became in small towns so high that the gas was too dear to use. Exchange was the principal cause, and constituted a great difficulty.

THE BUSINESS AT MALTA.

The Company were fortunate in being free from all Italian business. They had now only the business of Malta, where they had received just consideration from the authorities; and being a British Colony, there was no loss by exchange. The business had not been profitable during the war, which was not surprising, with coal costing £8 10s. per ton delivered at Malta. The last dividend paid by the Company was 2 p.ct. in 1918; but with the prospect of obtaining coal at 50s. per ton, the financial results were promising, and the Company should be able to pay a satisfactory dividend on the ordinary shares, as well as reduce the price of gas. The gas-rental at Malta last year was £53,812, against £65,353 in the previous year. This reduction was not due to a reduced sale of gas, which was only 4·79 p.ct. less than in the previous year, but to the reduced price of the gas, which was 13s. 8d. per 1000 c.ft. to August, 1921, and was reduced to 10s. by March 31, 1922, and had since been further reduced to 9s. per 1000 c.ft. The Directors looked forward hopefully to further reductions, with a reasonable cost of coal and freights. As was to be expected with the falling price of coal, coke realized much less; and last year the receipts for products were only £9365, against £20,347 in the previous year. There has been transferred a sum of £5869 from revenue account to reserve, which had been reduced to £130. The cost of coal, oil, and coke for producing the gas was £28,059, against £58,382. The average price of the coal was 98s. per ton. It was hoped this year to obtain it under 50s. per ton. The balance of revenue to transfer to profit and loss account was £11,239, against £8,631 for the previous year. Last year heavy charges of £4342 had to be met from profit and loss to meet the loss on exchange and to reduce the assets at the Sicilian stations. Fortunately these would not have to be met again. This so reduced the profit that after meeting a dividend on the preference shares and debenture interest, there remained only £214 to carry forward, which, added to the balance this year, gave £11,453. From this it was proposed to pay the dividends on the preference shares (less income-tax) and a dividend of 6 p.ct. (free of income-tax) on the ordinary shares, leaving a balance of £3498 to carry forward. The Company had passed through some years of the greatest anxiety. When the difficulties of sending coal to Malta during the war were realized, the shareholders must be thankful to have weathered the storm, and that the undertaking was in such a sound financial position, with every prospect of a satisfactory future. The aim of the Board would be to supply gas at as reasonable a price as possible. The Chairman concluded by moving the adoption of the report and accounts.

Mr. A. M. PADDON formally seconded the motion.

The CHAIRMAN, in reply to a question, said there was only £500 of debenture bonds outstanding; and this sum it was intended to pay off.

The report and accounts were then unanimously adopted.

On the proposition of the CHAIRMAN, seconded by Mr. STRACHAN C. CLARKE, dividends were declared at the rates of 6 p.ct. (tax free) and 7 and 7½ p.ct. (less income-tax) for the year, on the ordinary, first preference, and second preference shares respectively.

The retiring Director (Mr. A. W. Oke) was re-elected on the motion of the CHAIRMAN, seconded by Mr. PADDON; and the Auditors (Mr. E. L. Burton and Mr. William Cash) were re-appointed on the proposition of Mr. F. W. CHURCH, seconded by Mr. P. W. TIBBS.

The CHAIRMAN, proposing a hearty vote of thanks to the officers of the Company both in London and abroad, remarked that in Malta they had a most efficient staff. The results they were giving were excellent; and they had passed through a most trying time.

Mr. W. H. DODGSON seconded this, and it was passed unanimously.

The SECRETARY returned thanks on behalf of the staffs in London and in Malta.

A cordial vote of thanks to the Chairman and Directors for their services to the Company was then accorded, on the proposition of Mr. TIBBS, seconded by Mr. DODGSON.

Mr. W. H. DODGSON went on to remark that the accounts that had been presented that day showed an extraordinary improvement; and he was very pleased to see the position of affairs. All this represented much effort; and he would like, if it was possible without notice, to vote a sum of (say) £500 to be divided among the members of the Board, at their discretion.

This suggestion was seconded by Mr. A. D. DODGSON.

The CHAIRMAN said the Directors greatly appreciated the vote of thanks, and also the suggestion that they should receive some extra remuneration for the services rendered during the past few years.

Mr. E. L. BURTON pointed out that if the sum named could not be voted at the present meeting, the suggestion might be taken as notice of the intention to make the proposal at the next meeting.

Mr. PADDON said the shareholders had passed this vote in recognition of the efforts of the Directors; but he ventured to tell them that, if it ever eventuated, and the sum be applied, the Chairman should have the whole of it. During these troublous years, for all the success they had had in their long drawn-out contest with the Italian Government, they were indebted to Mr. Arthur Phillips. Without his guidance, they would never have got through. Mr. Phillips possessed peculiar knowledge of Italian affairs as bearing upon the gas industry; and it was he who had right along told them what to do and how to do it.

The CHAIRMAN said he most heartily appreciated the remarks by Mr. Paddon regarding the services that he (the speaker) had rendered to the Company. Certainly, the duties had been trying; but he was glad to see that his efforts were turning out successful. He hoped that a prosperous future would be his reward for any little that he had done.

The proceedings then terminated.

PLYMOUTH AND STONEHOUSE GAS COMPANY.

Annual Meeting.

The announcement of a further reduction in the price of gas at Plymouth was made by Mr. J. H. Ellis, the Chairman of the Plymouth and Stonehouse Gas Light and Coke Company, at the annual meeting on Tuesday of last week.

The Directors reported a balance of £36,131 to the credit of the profit and loss account, and recommended the payment of a dividend for the half year to March 31 of £6 3s. 9d. per annum on the ordinary stock, 9s. 10⅜d. per share on the additional shares, and 9s. 4½d. per share under the New Shares Act, 1879—less income-tax. This would absorb £10,682, leaving £25,449 to be carried to the credit of the current account. The Company's Order under the Gas Regulation Act became operative last Midsummer, with a charge for gas of 11d. per therm. Subsequent decreases in the cost of materials enabled the Directors to reduce the price at Christmas to 10·4d. per therm, and at Lady Day to 9·4d. per therm, despite the great fall in the selling value of residuals. The output of gas for the year had been satisfactory, notwithstanding the general trade depression.

In moving the adoption of the report, Mr. Ellis said the year had been an excellent one in many ways, yet full of anxieties. The causes of the anxiety were the two great labour disputes—the coal strike and the engineers' lock-out, from both of which they had suffered. But he was not sure that they had not been a blessing in disguise, for they had shown the remarkable flexibility of the industry. Just as the gas industry came to the succour of the country by supplying munitions of war and high explosives, so it came to the help of the country in the coal strike. But for the industry, there would have been a serious famine during the strike, and people would not have been able to have had as many cooked meals. This was one reason why gas securities were favoured by investors. As to their capital account, the debits totalled £13,876, due to the acquisition of the Plympton undertaking, &c. The credits were £62,835 in respect of redeemable debenture stock and £4241 written off prepayment installations. This, with £11,935 carried forward, accounted for the improved state of their banking account. These figures made a net credit of £60,200, converting a debit balance of £23,074 into a credit balance of £37,126. The total expenditure on the capital account amounted to £456,074, equivalent to £321 per million c.ft. of gas sold, against £328 last year. This was because their output had been greater, which was one of the causes of the prosperity of the Company. On the revenue account the total debits were £294,266, a decrease of £54,552. They had sales of gas £276,743, an increase of £11,820; and rentals of meters and stoves, £15,897, an increase of £2709. Coke realized £25,846, a decrease of £25,866; tar, £3976, a decrease of £22,854; and sulphate of ammonia, £2209, a decrease of £8839—making the enormous decrease on residuals of £57,559. After providing for dividends, &c., there remained a credit balance, subject to payment of a half-year's dividend, of £36,131 to be carried forward, compared with £24,196 the previous year. The cash at the bank at the close of the year was £6629, compared with a debit balance of £74,000 last year. Having acquired the Plympton undertaking, they shut down the works, and thereby effected considerable economies. He congratulated Mr. P. S. Hoyte (the Engineer), the staff, and the workmen engaged in the task on their smartness and expedition. The material was ordered in anticipation of their legal powers; and the very day they were granted the work was well under way. It was finished in less than seven weeks. The laying of 2¼ miles of 6 in. main in this time was something to be proud of. So far they had every reason to be gratified with the results. The route of the new main along the road to Plympton had already yielded many additional customers, and held out excellent promise of future development. Substantial progress had been made at the works with a new and commodious distribution department, extended and improved workshop and laboratory accommodation, and new condensers for the carburetted water-gas plant; while the purifiers so long needed had been nearly completed. They looked forward to the time when those purifiers would be in operation and enable them to supply gas equal to the pre-war standard of purity. It was not merely their policy to provide good gas at adequate pressure, but also cheap gas. Their standard price was fixed at the exceptionally low figure of 12 6d. per therm. They had twice reduced it; and it was with the liveliest satisfaction that he announced that they had that day decided to further reduce it to 9d. per therm. This would be an enormous boon to their customers, and incidentally it would increase their dividend for the September half year by 5s. p.ct. He did not wish to raise false hopes; but he hoped, and believed, they would be able to make another reduction when their consumers most needed it—in the coming winter. The national wages agreement had worked equitably. The results disclosed a sounder and better position than many of them dared to hope for. Their position was due in part, and very largely, to the fall in the prices of their raw material, and in part to the Gas Regulation Act. They would be wanting in fairness, however, if they did not publicly acknowledge the ability, zeal, and industry which Mr. Hoyte, Mr. G. H. Bolton (the Secretary), and all the staff had displayed in the discharge of their duties. He also referred to the 59 years' service with the Company of Mr. W. Ford, foreman of fitters, who had just retired. As a recognition of faithful service, the Directors had made provision for his retirement.

The report and accounts were adopted.

Fatality at the Plymouth Gas-Works.—A Plymouth Gas-Works labourer, Frank Tresize, while engaged in painting the lattice work of a gasholder, fell from a height of about 50 ft., and was killed. The inquest was held by the Borough Coroner (Mr. R. B. Johns), when it was stated by Mr. P. S. Hoyte (the Engineer) that the holder had been painted yearly by the same method since 1896; and they had no reason to doubt that it was a safe one. A verdict of "Accidental death" was returned; and the Inspector of Factories said there was no negligence on the part of the Company.

LINCOLN CORPORATION ACCOUNTS.

Reporting upon the accounts of the Lincoln Corporation gas undertaking for the year ended March 31 last, Mr. J. H. Burgess (the City Treasurer) says that the loss on the trading account for the year was £678; and service of debt and interest charges amounted to £8736, leaving the deficit on the year's working £9414. Towards this the accumulated balance in hand was £9086, leaving an adverse balance at the close of the year of £328.

Compared with last year's net profit of £5527, this is a difference of £14,941 for the year, and is attributable to: (1) A fall of £11,739 in the amount realized by the sale of residuals; (2) an increase of £5776 in the working expenses, mainly due to the additional cost of coal bought during the miners' strike; (3) the high cost of labour, materials, and rates; and (4) the fact that the price of gas was kept rather too low, having regard to these exceptional circumstances.

Lighting and power revenue increased by £2474, though the restricted supply during the strike was responsible for a considerably decreased demand; and, with the prospect of reduced cost of labour and material, it seems, says Mr. Burgess, reasonable to anticipate that if the price of gas be continued as at present, at 4s. per 1000 c.ft., the coming year will recoup the loss, provided the price of residuals does not fall much below its present level. It is desirable that the consumer should understand that, while most other towns were increasing their prices to a much higher figure, the price in Lincoln was maintained at 4s. per 1000 c.ft.; and that, even now, this price is still much below that being generally charged.

The value of works, plant, and other assets of the undertaking, taking the works, &c., at cost, and after making substantial allowance for the depreciation of cookers and meters, is £290,590. The total liabilities are £104,740 (of which £87,878 represents outstanding loans); and there is therefore a balance of assets amounting to £185,850, or £97,972 more than the loan liability. The income for the past year was £113,449, and the expenditure £122,863.

The Gas Manager (Mr. W. H. Mainwaring) reports that the quantity of gas made during the year was 8,061,000 c.ft. less than last year. The curtailment of the supply to the city at certain hours of the day during part of the coal strike was responsible for nearly double this amount; and, apart from this, the consumption of gas would have maintained the normal rate of increase. As the strike continued for more than three months, even a partial supply was only maintained by a large expenditure on English and foreign coal, most of which was of a very inferior quality, and affected the working results accordingly. In common with other towns, Lincoln complied with an Order of the Board of Trade to utilize the water-gas plant to its utmost capacity. During the strike it was, for the first time, worked through the whole 24 hours; and it was undoubtedly the means of preventing a complete stoppage of the supply of gas to the city.

Further progress has been made in the direction of ensuring an efficient service to those portions of the district which are more remote from the works; and this work is still in hand. Large expenditure has also been necessary in connection with the housing schemes, for mains, service-pipes, meters, &c. These schemes have been responsible for a total outlay to date of no less than £10,360. The collapse of the market for tar and sulphate of ammonia, which was reported last year, continues, and is responsible for heavy comparative losses on these items. Coke, which up to the present has well maintained its value, appears to be losing its stability; and the prospect for the future is very unpromising, as far as residuals are concerned.

Mr. Mainwaring proceeds: "It was decided not to take advantage of the Temporary Increase of Charges Order, which we obtained in September, 1920; and our price of 4s. per 1000 c.ft. has not been increased since Midsummer of that year. In this respect we have not followed the example of the great majority of undertakings in this country, many of which, with a pre-war price approximately the same as our own, advanced their rate from 1s. to 2s. per 1000 c.ft. in excess of what we were, and are, charging. The obvious result has been that these undertakings are now able to show a profit, and to announce reductions in the price of gas. In view of the serious loss of revenue we have sustained, and the heavy cost incurred during the coal strike, neither of these has been practicable so far as we are concerned. In this connection, it may be pointed out that, on our present consumption, an advance of 1s. per 1000 c.ft. is equal to an increased yearly revenue of upwards of £19,000."

The total quantity of gas made was 417,067,000 c.ft., as compared with 425,128,000 c.ft. in the previous year. Of this quantity 82,481,000 c.ft. was carburetted water gas, as against 57,141,000 c.ft the year before. The gas made per ton of coal last year was 12,052 c.ft., compared with 12,280 c.ft. in the preceding year.

Dunfermline Gas Profit.—The gross profit for the year's working of the Dunfermline Gas Department is £18,146, to which has to be added a balance from the previous year of £756. After deducting interest, &c., the credit balance is £5069.

Droitwich Gas Accounts.—The annual gas returns and Manager's report on the year's working of the undertaking were presented to the Droitwich Lighting Committee recently. Reviewing the position, the Chairman (Alderman J. Gabb) stated that the make of gas (37,359,200 c.ft.) was down by about 3 p.ct. compared with the previous year; and the sales were also down in about the same proportion, due to the coal strike. The revenue account showed that receipts from gas (£9642) were up by about £90, owing to the fact that this was the first full year of the increased price of gas—5s. per 1000 c.ft. On the expenditure side, coal had cost £200 less. The profit on the year was £858; and there was a net sum of £2674 to the credit of the undertaking. The Chairman, on the question of the price of gas, said he had gone into the matter carefully with the Manager; and having regard to the cost of coal and wages, they would not be able to reduce the price by more than 4d. per 1000 c.ft. over the full year. If, however, they reduced it from July 1, he thought they could make the reduction 6d., from 5s. to 4s. 6d. This proposition was agreed to.

WALSALL GAS ACCOUNTS.

The Gas Committee of the Walsall Corporation in their report for the year ended March 31 state that there is a net loss on the year's working of £3177, as compared with a net loss for the previous year of £6288. Having regard to the anxious period through which gas undertakings generally have had to pass, by reason of the prolonged coal strike and the continued depression in trade, the Committee consider that it cannot be deemed an unsatisfactory report, and that the financial results which have been obtained during the last six months have been of an encouraging character. The Committee point out that there has been, in consequence of such abnormal depression in trade, a large reduction in the amount realized by the sale of residual products; also that there has been a loss sustained by the gas undertaking by reason of the small amount they have received for public lighting. Now that coal is being obtained at a greatly reduced price and the cost of labour and materials is falling the Committee consider that a reduction in the price of gas to consumers can be made. As from the reading of the meters for the June quarter, therefore, the price of gas supplied will be reduced as follows:

Within the Borough.

Ordinary consumers: Flat rate of 4s. 6d. per 1000 c.ft.
Slot meters: A reduction of 3d. per 1000 c.ft.
Gas used for power purposes:

Up to 100,000 c.ft. per quarter	4s. 4d.	per 1000 c.ft.
100,000 to 150,000 c.ft. per quarter	4s. 3d.	,, ,,
150,000 to 200,000 c.ft. per quarter	4s. 2d.	,, ,,
200,000 and over c.ft. per quarter	4s. 0d.	,, ,,

Pelsall, Shelfield, Aldridge, and Great Barr.

Ordinary consumers: 5s. 3d. per 1000 c.ft.
Slot meters: 5s. 6d. per 1000 c.ft.
Subject to a discount of 2½ p.ct. to all power and ordinary consumers on the usual terms of payment.

The Committee are convinced that in the interests of the undertaking a sliding-scale for gas used for power purposes must be adopted. Such a scale was formerly in use, and since the differential rate was abolished the undertaking has lost an increasing number of large consumers.

The Committee have reconsidered the recommendation they made in regard to the application to the Board of Trade for an Order under the Gas Regulation Act, 1920, and they are of the opinion that the maximum price per therm should be 1s. 4d. instead of 1s. 6d., as before recommended. A Sub-Committee, consisting of the Chairman, Vice-Chairman, Alderman Cope, Messrs. Forsyth, Hucker, and Warner, have been appointed for the purpose of investigating the management of the gas undertaking in all its branches, and to report thereon.

BORROWING POWERS AT LOUGHBOROUGH.

The necessity of building-up a reserve fund commensurate with the needs of the undertaking was enforced by Mr. H. R. Hooper, one of the Government Inspectors, when holding an inquiry at Loughborough last Wednesday, into an application by the Corporation for leave to borrow £8879 for the extension of the gas-works, purchase of meters, &c.

The Town Clerk explained that the outstanding municipal loans, including those in connection with housing, education, and the borough fund, amounted to £588,677; and the overdraft on capital account was £369. They did not anticipate any opposition to the application. The first portion of the money (£1604) represented excess expenditure on the extension of the gas-works. Under the Corporation's Act of 1899, powers were conferred upon them to borrow £40,000 for the extension of the works, which sum had now been exceeded. Of the total amount asked for £1000 was for new mains and services, which they anticipated would probably serve the town for two or three years, £300 for new ordinary meters, which were not procurable during the war period, £200 for slot-meters, and £300 for stoves. The water-gas plant was no longer reliable; and the Committee felt it was necessary to have a stand-by. If the water-gas plant broke down at present, they would not be able to give the town a full supply of gas from the retorts. The Inspector observed that the Corporation had at present £2000 outstanding on a derelict plant; and they were having to spend practically £5000 because the plant was no longer efficient. The Town Clerk expressed his inability, however, to acquiesce in this view of the situation; pointing out that there was still a good deal of usefulness in the plant. The Inspector asked for an explanation of the overdraft on the capital account of £6360. The Town Clerk said that when the amounts raised by the Finance Committee under the borrowing powers were paid over to the Gas Department, the sum would be reduced to £2650, which was the total of the excess expenditure.

Having gone into the whole of the figures, the Inspector said his advice to the Corporation was that a reserve fund should be built-up. The Corporation had no reserve fund, and still had to pay on a plant which was worn out. In other words, during the five years they were making profits they were not paying off at the rate of depreciation. There now came lean years, and they found themselves with a big overdraft and no reserve fund. This was not as it should be. The Town Clerk said he quite agreed.

In proposing a vote of thanks to the Inspector, the Chairman of the Gas Committee expressed his belief that the searching inquiry which had taken place would prove useful to the Committee in days to come.

Mansfield's Cheaper Gas.—The encouraging information was forthcoming at a meeting of the Mansfield Town Council last Friday evening that, consequent upon the reduction in coal prices, the Gas Committee (of which Alderman Smith is Chairman) had seen their way to reduce the rates charged for gas by another 3d. per 1000 c.ft. for the quarter ending Sept. 30 next.

SULPHATE OF AMMONIA PRICES.

For July and August Delivery.

The British Sulphate of Ammonia Federation, Ltd., in a circular issued to fertilizer manufacturers, agricultural merchants, and co-operative societies, announcing the prices at which sulphate of ammonia will be supplied for home agricultural use during the summer months, state that they propose to follow their usual custom of raising prices gradually during the remainder of the season. To this end they have fixed their summer prices at a level considerably below what they were obtaining for export. They remark that the production of neutral sulphate of ammonia is rapidly increasing, and they expect that the bulk of their deliveries will henceforward be of neutral quality. They reserve to themselves, however, the option of delivering ordinary quality in some districts subject to allowances in price stated in their circular.

The price for July and August delivery will be :

£16 3s. per ton for neutral quality in fine friable condition, free from lumps, basis 25¾ p.ct. ammonia.

Delivered to consumer's nearest station or wharf in Great Britain, for prompt cash payment, in lots of 4 tons and upwards.

Limited quantities of ordinary quality will be available in some districts, and will be sold at 23s. per ton less than the above prices, basis 25¼ p.ct. ammonia.

To fertilizer manufacturers, agricultural merchants, and co-operative societies registered under the Friendly Societies Acts, or any other Act, a commission of 12s 6d. per ton will be allowed on all deliveries.

The foregoing prices do not apply to orders for Ireland or the Channel Islands.

ANNUAL REPORT AT WORKINGTON.

Reporting to the Gas Committee of the Borough of Workington on the results for the year ended March 31, Mr. Hedley Hoy (the Engineer and Manager) says that during the coal stoppage, when coal had to be obtained from any available source, regardless of quality, the supply of gas was maintained with comparatively slight restrictions. The gas made per ton of coal during this period was 16,977 c.ft.; and for the last nine months, 19,688 c.ft.—a record for the department. The inferior coal used during the first three months had a serious effect on the quantity and quality of the residuals; the coke, tar, and ammoniacal liquor produced being of very little value. Since the end of the coal stoppage, trade has not recovered in the district; and the period has been the worst experienced for some years. But notwithstanding this, the results of the year's working have come out well. Residuals depreciated in value considerably during the year, especially tar. The tar prices obtaining in the previous year were exceptionally high, and not likely to recur again. The net return from residuals was 42·64 p.ct. on the cost of coal, against 58·35 p.ct. in the preceding year. There was a considerable decrease in the gas unaccounted for.

The gross profit this year is £6192, against £5045 in the preceding year. The net profit is £1129, against £1357. The total make of gas was 151,630,000 c.ft., as compared with 163,544,000 c.ft. in 1920-21—a decrease of 7·28 p.ct. The unaccounted-for gas was 3·91 p.ct., against 6·55 p.ct. a year ago.

In presenting the accounts to the Council, Alderman Hall said the results reflected the highest credit on the Engineer and his staff.

Dundee Gas Accounts.—It was stated at a meeting of the Law and Finance Committee of the Dundee Town Council that the accounts of the Gas Department for the year just closed showed a debit balance of £46,655. The year began with a debit balance of £23,951, making the total debit balance to be carried forward £70,606. The deficit is explained by the fall in the values for coke, tar, and sulphate of ammonia. The estimates for the present year show income £349,270, and expenditure £366,787, leaving to be carried forward £17,517 debit balance.

Price of Gas at Dudley.—Alderman Lloyd reported to a meeting of the Dudley Town Council on Tuesday, June 13, the receipt of a letter from the Gas Company stating that as from the June reading of the meters the price of gas would be reduced 3d. per 1000 c.ft. for lighting, and 6d. for industrial gas, with the reintroduction of a fair scale for large power consumption. This represented a decrease in the last six months of 6d. for lighting and 1s. to 1s. 3d. for industrial purposes. He (Alderman Lloyd) said the Gas Company had declined to receive a further deputation on the matter. Mr. Smellie thought that, while they had not got all they thought they were entitled to, the reductions were reasonable; and they ought to be satisfied. Mr. Ballard said the Gas Company had been profiteering for years. Manufacturers should combine to provide competition. No action was taken in the matter.

Coke-Oven Gas Supply at Chesterfield.—For some time past the Grassmoor Colliery Company have been supplying the Corporation of Chesterfield with coke-oven gas at a fixed price of 1s. 6d. per 1000 c.ft. On being approached for an increased supply, the Company offered to let the Corporation have the additional amount required at 1s. 3d. per 1000 c.ft., with a sliding-scale of 2d. per 1000 c.ft. for every rise or fall of 1s. per ton in the cost of gas coal as supplied by the Grassmoor Company to local gas-works. The Corporation declined this proposal, and offered to pay 1s. 2d. per 1000 c.ft. if the Grassmoor Company would undertake to meet the sinking fund and interest charges on the mains and meters connecting the coke-ovens with the Corporation holders. It has been said that, if the Corporation can purchase gas at 1s. 3d. per 1000 c.ft., it is strange that they cannot sell gas to consumers at less than 4s.—the present price; but Mr. Harold Davies (the Corporation Gas Engineer) points out that the charges for rates, taxes, distribution, &c., amount to 2s. 10d. per 1000 c.ft.

SOUTH SUBURBAN GAS COMPANY.

Athletic Sports and Co-Partnership Meeting.

The Athletic Sports of the South Suburban Gas Company were held in the grounds of the Crystal Palace last Saturday, when a large number of co-partners and friends assembled to witness the interesting items that had been arranged. There were 24 events, all of which were keenly contested, and showed that the Company possess many really good athletes. Some of the events produced moments of excitement, especially during the "Tug of War," in which, after a strenuous struggle, the Sydenham (Water Gas) Team were the winners. The prizes were subsequently distributed by Miss Hunt, who was enthusiastically accorded a vote of thanks on the call of Mr. H. M. Ellis, the Hon. Secretary of the Sports. The Silver Cup, presented by Mr. Charles Hunt in 1920, which is to be held for one year by the competitor scoring the highest number of points during the sports, or to become the absolute property of any competitor holding the Cup three years in succession, was on this occasion won by Mr. G. Mack (Sydenham). Mr. J. Terrace (the Chief Engineer of the Company) acted as Referee; while the Judges were: Messrs. W. Wastell, W. Judd, W. G. Waller, H. Baldry, B. P. Bezant, and F. G. Gorman. At the conclusion of the sports, a move was made to the Concert Hall, where Mr. Charles Hunt (the Chairman of the Company) presided over the Co-partnership meeting. He was supported on the platform by Dr. Charles Carpenter, Mr. H. Gundry, Mr. B. R. Green, Mr. J. H. Boraston, Mr. W. G. Waller, Mr. E. P. Norton, Mr. J. Terrace (Engineer), Mr. Wilfrid Wastell (Secretary), and Mr. Baker (the Secretary of the Co-partnership Committee).

The CHAIRMAN (who was received with cheers) expressed, on behalf of his colleagues and himself, the great pleasure they felt at meeting the co-partners once again. Referring to the year's work, he said that it had opened with a full tide followed by a slack tide. Regarding the lowering of wages, he mentioned that co-partnership had solved the difficulty attendant on the reduction of wages. He spoke of the useful work that had been done by the Works Committee during the past year. He also mentioned that they had, a few days since, received from the Ministry of Labour a certificate of exemption from the unemployment tax. It was two years since they made the application; and he was glad that the matter had now been satisfactorily settled.

Mr. C. J. CARTER (the Secretary of the Works Committee) next gave a *résumé* of what had been done by the Works Committee during the eleven months since the meeting held in July of last year. His report showed that good and useful work had been accomplished by the Committee. Referring to adverse criticisms that had been made—particularly in regard to the reduction of wages—he stated that the Chairman had given an undertaking that wages should not fall to pre-war level. The Committee's aim and supreme object had been to carry out to the full extent the functions that had been committed to them, with the idea that they should not be an unworthy part in the machinery of their co-partnership system.

The adoption of the report, which was moved by Mr. J. W. ANSETT and seconded by Mr. F. REED, was carried unanimously.

Mr. H. GUNDRY spoke of co-partnership as a sturdy plant. They had seen that day what the co-partners could do at play; the standard of athleticism was very good. He expressed the hope that co-partnership might long flourish.

Dr. CHARLES CARPENTER did not agree with the previous speaker in likening co-partnership to a sturdy plant. It was more; it was a sturdy tree. He went on to refer to the strength of co-partnership. Its object was to combine the interests of two or more people.

Mr. J. H. BORASTON and Mr. W. G. WALLER also addressed the assembly.

Mr. WILFRID WASTELL proposed a hearty vote of thanks to Mr. Charles Hunt for presiding over the gathering, remarking that their Chairman was never too tired to take an interest in anything that concerned the welfare of the employees.

This vote was carried with enthusiasm. The members then proceeded to the Fountain Café, Restaurant, or Grill Café (according to the colour of the ticket which they held) for tea.

The singing of the National Anthem brought the official programme to an end; and thus concluded another red-letter day in the history of the co-partnership system of the South Suburban Gas Company.

Reduction at Skipton.—The Skipton District Council recently decided to reduce the price of gas, as from July 1, by 7½d. per 1000 c.ft. to ordinary consumers, and by 7d. to prepayment meter consumers, making the new charges 3s. 9d. and 4s. 0½d. respectively.

Lisburn Gas Undertaking.—At a meeting of the Lisburn Urban District Council, a report on the working of the gas undertaking for the past twelve months was presented. It showed that a profit of £5316 had been realized—the highest figure reached during the period in which the concern has been under the administration of the Council. Mr. Skillen (the Chairman of the Gas Committee) and Mr. A. S. Brook (the Gas Manager) were complimented on the satisfactory result; and it was mentioned that the Committee contemplated an early reduction in the price of gas.

Proposed Further Reduction at Birmingham.—The Birmingham Corporation Gas Committee will recommend to the City Council that another reduction be made in the price of gas to ordinary consumers. It will not be less than 6d. per 1000 c.ft., and may be a trifle more than that figure, as the Committee desire to bring the charge below 4s. The reduction in prospect will be the third to be made this year. Last year the price was 5s. 6d. per 1000 c.ft., which by two instalments of 6d. each, was brought down to 4s. 6d. If the price can be reduced to 3s. 10d., it will be the same as that which obtained in July, 1919. The pre-war price of gas to private consumers was 1s. 11d. per 1000 c.ft. It is stated that very substantial reductions have been effected in the cost of administration, largely as a result of lower coal charges, though the residual market is still very unsatisfactory.

TRADE NOTES.

The Tully Gasification Plant.

A lot of information on the subject of their particular system of gas making is to be found in the latest catalogue of Tully Gas Plants, Ltd., of Millgate, Newark-on-Trent. The fact is recalled that the first Tully plant was the joint invention of the late Prof. V. B. Lewes and Mr. C. B. Tully, some twenty years ago. At that time the plant was designed on the lines of the Dellwik water-gas apparatus; but the hot blow gases, instead of being discharged immediately into the air, were utilized to heat a column of coke over the producer. The Tully plants of to-day embody the same idea; but they have been modified to enable any class of coal to be gasified, providing it is moderately free from dust. With excellent photographs and drawings, a clear and concise description is given of the plant, which consists of a generator, a wash-box, a blower with primary and secondary air blast, and a boiler for the injection of steam—fitted in such a manner that all the operations can be performed by one man. One of the drawings shows the general arrangements of two units of Tully plant of 500,000 c.ft. per day capacity each, fitted with carburettors for gasifying oil and waste-heat boilers. The advantages of the system are set forth, among them being its simplicity of operation and its low capital and maintenance costs. It is said that the upkeep and maintenance of a Tully plant will not exceed 0·5d. per 1000 c.ft. made, including re-lining the producer and upkeep of machinery. Many figures are given to show what the plant can do; and it is stated that a number of towns are now supplying nothing but Tully gas, with most satisfactory results, and a total freedom from complaints. A list is given of some 150 orders for plants received since 1919; at the end of a well got-up booklet, there are named as suitable fuels for the Tully plant, woody substances containing oil, coke, and most coals (with the exception of anthracite, bituminous slack, fine coke breeze, and fine non-coking coal). A selection should be made of a coal containing an ash that will fuse at 1400° C.

"Newbridge" Automatic Lighting.

A new descriptive booklet on automatic lighting, with an introduction on the principles and economy of the automatic control of street lamps, has been issued by the Horstmann Gear Company, Ltd., of No. 93, Newbridge Road, Lower Weston, Bath. It is interesting to learn from this that the automatic operation of gas at pre-determined times for lighting and extinguishing of burners has been in practice for about a hundred years. Rotary gas-plugs were often used in this way as a means of illuminating clock dials—flat-flame burners being turned up and down by the motion of the clock. It was some time later that clock-work devices were first used for the lighting and extinguishing of street lamps; and one of the first-recorded instances of the employment of what are now known as gas-controllers was in 1868. The inventor of the arrangement suggested then was Dr. Thurgar, a Norwich surgeon. Eighteen years ago the first model of the present "Newbridge" controller was placed upon the market—the inventors having been originally watchmakers, and so used to making instruments of precision. At first business was carried on in Union Street, Bath; then in larger premises at Walcot Street; while now the large plant erected at the Newbridge Works has become necessary. It was with this plant that during the great war gauges were made to limits of one-hundred-thousandth of an inch. The same plant and the same large staff are now producing "Newbridge" controllers. The booklet sets forth the advantages of automatic lighting, and then describes at length, with illustrations, the different types of "Newbridge" controller. There is an extinguishing pilot controller, suitable for use on all types of "Newbridge" controllers, by which the bye-pass is extinguished during lighting hours—resulting in still further economy. There is also a gas-main controller for the automatic operation of large gas-cocks, in connection with the lighting of groups of lamps, and for other uses. But whatever the type, the workmanship is of the best—cut and topped wheels and solid steel pinions being used throughout.

Imperial Continental Gas Association Award.

The City Notes of "The Times" last Monday contained the following: Questions have recently been asked as to when stockholders in the Imperial Continental Gas Association might expect a distribution on account of the settlement of their German claims. This settlement was effected last November; the amount being agreed at £1,600,000. But, as we explained at the time, a delay of some months was probable before the money would be paid over. Settlement has already been made of the Association's claim in respect of pre-war debts and of the proceeds of actual liquidation of property; and the claim in respect of which payment has yet to be made is to meet the inadequacy of the Liquidator's payment, *plus* a certain amount of interest. It is understood that the requisite order to make the payment to the Association is conditional on evidence being given by the Public Trustee that he is satisfied there are sufficient funds available to meet the admitted claims of all British creditors arising, not only in respect of pre-war debts and actual liquidations, but those which, like the Imperial Gas Association's final claim referred to, come under Article 297 of the Treaty. The task of the Public Trustee in liquidating the properties of ex-enemy nationals is necessarily one that requires time for its final accomplishment, though as such property was reported some time ago to be worth about £110,000,000, and the claims of British nationals were originally about £90,000,000—and have since been substantially reduced—the outcome of the liquidation should enable all creditors to be paid in full, with a comfortable margin to spare.

Accident to a Holder at Ashton.—A large quantity of gas was lost (about a million c.ft.) through the collapse on Sunday at Ashton-under-Lyne of a gasholder. This holder was damaged at the time of the disastrous munition works' explosion five years ago.

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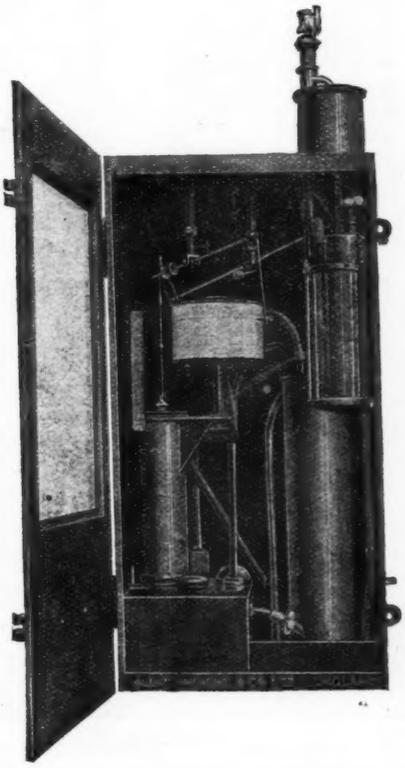

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CURRENT SALES OF GAS PRODUCTS.

The London Market for Tar, Tar Products, and Sulphate.

LONDON, *June* 26.

There is a good inquiry for pitch for next season's delivery; the price being called at from 75s. to 77s. 6d. per ton in bulk. Creosote is steady at about 6½d. per gallon net and naked at makers' works. There is a fair demand for solvent naphtha at about 2s. 6d. per gallon for 95-160 quality. Pure toluene is about 2s. 9d. per gallon. Naphthalenes are in fair demand. Other products remain without particular change.

Tar Products in the Provinces.

June 26.

Markets for tar products generally have again been very steady throughout the week. In pitch there are considerable inquiries both for prompt and forward delivery. At present, however, buyers appear to be unwilling to pay the prices indicated; and it is doubtful at the moment whether they can sell fuel at figures which would warrant the price of pitch now, unless there is a considerable fall in small coal, which latter event will probably occur before very long. The creosote market is very firm indeed: and it is understood that some quantity is still wanted in America. In this respect, the fall in the value of sterling in New York may assist matters. Benzole is quiet, but is apparently moving off in fair quantities for motor purposes. Solvent and heavy naphtha are both neglected. Carbolic and cresylic acid remain steady. There does not appear to be any inquiry at present for naphthalene.

The average values for gas-works products during last week were: Gas-works coal tar, 40s. 6d. to 45s. 6d. Pitch, East Coast, 72s. to 74s. f.o.b. West Coast—Manchester, 68s. to 70s.; Liverpool, 69s. to 71s.; Clyde, 71s. to 72s. Benzole 90 p.ct. North, 2s. to 2s. 1d.; crude 65 p.ct. at 120° C., 1s. 2½d. to 1s. 4½d. naked at makers' works; 50-90 p.ct., naked, North, 2s. to 2s. 1d. Toluole, naked, North, 2s. to 2s. 3d. nominal. Coal tar crude naphtha in bulk, North, 8½d. to 9½d. Solvent naphtha, naked, North, 1s. 8d. to 1s. 10d. Heavy naphtha, North, 2s. to 2s. 1d. Creosote, in bulk, North, liquid, 5d. to 5¼d.; salty, 4¾d. to 5d. Scotland, 4⅝d. to 4⅝d. Heavy oils, in bulk, North, 6¼d. to 6½d. Carbolic acid, 60 p.ct., 2s. to 2s. 1d. Naphthalene, £12 to £15; salts, £5 to £5 10s., bags included. Anthracene, "A" quality, 5d. to 6d. per minimum 40 p.ct. nominal—no business doing; "B" unsaleable.

FROM A MARKET CORRESPONDENT.

Bye-Products Trade.

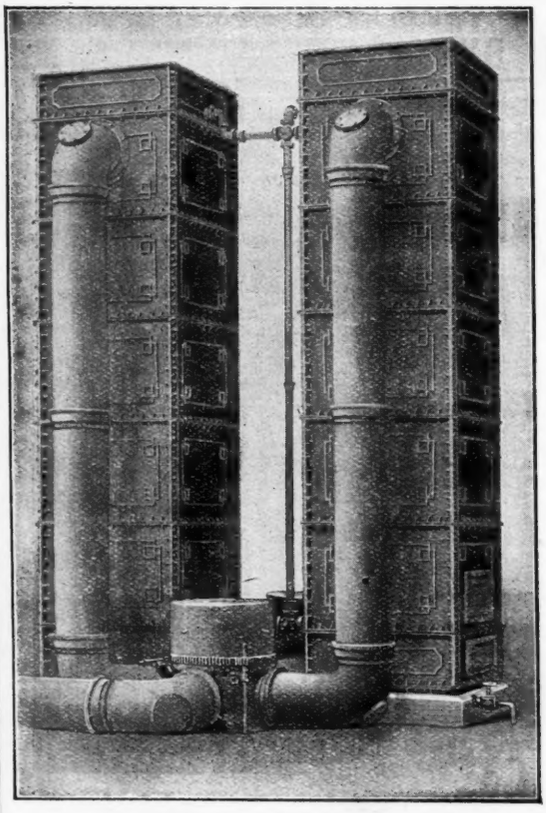
Since my last report there has been an improvement in this market, particularly with regard to pitch. This is now quoted at from 67s. 6d. to 77s. 6d. per ton, according to district. There is a good demand for this material for road repairing purposes, and the trade in patent fuel is also getting better. On the other hand, there are reports that Continental buyers are not keen in following the upward movement. At the same time, we have to bear in mind that this is not the season for shipping this material across the water in bulk. On the whole, it is generally thought that the lowest prices have been seen for the present season, as although the production may increase during the summer and autumn of this year, it is fairly certain that the total output for the twelve months will be a low one. Solvent naphtha and benzole are dull with lower prices; solvent selling at 1s. 9d. and benzole 90 p.ct. at 1s. 11d. per gallon. Creosote remains fairly firm at 5d. to 5¼d. per gallon, although from the North 5¾d. is quoted. Carbolic acid is without change—1s. 9d. per gallon for crude and 6½d. per lb. for crystals. Cresylic acid is fairly firm at 2s. 3d. to 2s. 4d. per gallon. Naphthalene is still in poor demand, and quotations are unchanged. Business in intermediate products has been rather quieter since my last report, with less inquiry on home account but rather more on foreign account. There are no changes in prices.

Sulphate of Ammonia.

The home trade remains dull; but there is rather more inquiry for export. The Federation have now issued their prices for July and August deliveries as follows: £16 3s. per ton for neutral quality 25⅝ p.ct. ammonia. A limited quantity of ordinary quality (basis 25¼ p.ct. ammonia) will be available in some districts at £1 3s. per ton less than the foregoing. In making this announcement, the Federation point out that, owing to bad trade conditions, the total production of sulphate of ammonia, both here and abroad, is still below normal, and it is essential that orders should be freely placed for summer and autumn delivery if the demand for the whole season is to be met. Prices for September and later months will be announced in due course.

Price Reduction at Burnley.—The Burnley Corporation Gas Committee have decided to reduce the price of gas 2d. per therm (9½d. per 1000 c.ft.), and to maintain the present quality of 475 B.Th.U.

Gas at Keighley.—The Keighley Town Council, last Tuesday week, decided to reduce the price of gas for all purposes by 5d. per 1000 c.ft.—to 3s. 2d. per 1000—as from July 1. The last increase of price was on July 1, 1920. The new price is substantially below that of most surrounding gas authorities. No increase was made for Keighley gas as a result of the coal stoppage last year, although that period cost the Department something like £9000. The net estimated profit for the year was stated by the Chairman of the Gas Committee (Mr. W. H. Murgatroyd) to be £5759. The reduction of 5d. was equal to £7200, so that there would be an estimated deficit of £1441, which the Committee hoped to turn into a profit from other sources before July 1 of next year.



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STOCK MARKET REPORT.

THE general tone of things on the Stock Exchange last week, after a fair opening, altogether gave way, and markets all round became dull to a degree. The gilt-edged was a conspicuous sufferer, and Home Government issues fell freely. But on Thursday a recovery set in, which lasted through Friday, when the big four showed the following improved figures—viz., Consols 56⅛-57, War Loan 99¾-100 3/16, Funding 85⅛-85⅝, Victory 89-89½. Home Rails experienced more difficulty, and effected only a partial rally. Canadians and Argentines were down. The Foreign Market was weak generally; Peruvian, Brazilian, Chinese, Japanese, and Mexican notably. In the Miscellaneous group, Rubber was dull. Oil was fair, but for a weak spot or two.

Business in the Gas Market was a good deal quieter, as if taking breath after its long career of brilliancy and booming prices. This is healthy. It is not well to overdo a good thing: the return swing of the pendulum may hurt. However, there was no sign of weakness, only a cessation of big jumps. Modest advances were a rise of 1 in Gas Light ordinary, and 2 each in Brentford "A" and "B." Cape Town preference was ⅜ higher. Imperial Continental was not much dealt in. Primitivas were quiet, and the preference fell ¼.

The following transactions in gas during the week were recorded: On Monday, Commercial 3½ p.ct. 93⅜, Croydon "C" 150, European 12⅜, Gas Light ordinary 96⅛, 96½, 96⅜, 97½, 97½, 97⅜, 97⅞, 98, ditto preference 78, 79, ditto debenture 62½, 63, Imperial Continental 163½, ditto debenture 78, Primitiva 15s., 15s. 10½d., 16s., ditto preference 40s., 43s. 9d., South Metropolitan 96⅜, 97½, 97⅝, South Suburban debenture 95, Wandsworth Wimbledon 95, 95½, Liverpool 7 p.ct. preference 106. On Tuesday, Brighton and Hove "A" 121, 122, Commercial 4 p.ct. 93½, 94, European 12½, 12⅜, Gas Light ordinary 96⅜, 97½, 97⅜, 97⅝, 97⅞, 98, ditto preference 77, 77⅛, 77⅜, ditto debenture 62⅛, 63½, 64, Imperial Continental 163, 163½, North Middlesex 7 p.ct. 11⅛, South Metropolitan 96⅜, 97, Wandsworth Wimbledon 93½, 96, Barnet 4 p.ct. debenture 72½, 73. On Wednesday, Commercial 4 p.ct. 93⅜, Gas Light ordinary 97, 97½, 97⅜, 97⅞, 98, ditto preference 77⅛, 78, ditto debenture 62½, Imperial Continental 162½, Primitiva 14s. 9d., ditto preference 40s., South Metropolitan 96⅜, 97½, ditto 6⅛ p.ct. debenture 101, 101½, 101⅜, Wandsworth Wimbledon 96, Swansea 7 p.ct. preference 102½, Torquay 7 p.ct. maximum 7⅞, 8. On Thursday, Bombay 4½, Brentford "B" 92⅛, Commercial 4 p.ct. 93½, ditto 3½ p.ct. 93⅜, ditto debenture 57, Continental Union 38⅛, ditto preference 56, European 12½, Gas Light ordinary 97, 97½, 97⅜, 97⅞, 98, ditto preference 77⅜, 77½, 78⅛, 78⅜, ditto debenture 62½, 63½, Imperial Continental 163½, Primitiva preference 41s. 6d., South Metropolitan 96½, 97½, ditto 6½ p.ct. debenture 105, 106½, South Suburban 100½, 100¼, 100⅜, Wandsworth debenture 58, Croydon 4 p.ct. debenture 77, 77½, Southend 4 p.ct. debenture 76, 76½. On Friday, Brentford "B" 93, 93½, 93⅜, Gas Light ordinary 97, 97½, 97⅜, 97⅞, ditto preference 77½, ditto debenture 64, Imperial Continental 163, ditto debenture 74, Primitiva preference 41s., River Plate debenture 57½, South Metropolitan 96⅜, Southend 4 p.ct. debenture 76½, Mid-Kent 14s., 14s. 6d., Toronto Consumers 154.

In the Money Market, the position fluctuated at short intervals from a fairly pronounced demand to full relaxation and back again, but at the close easiness was established. Discount rates alternated sympathetically. Silver was a fraction lower. The Bank rate is 3½ p.ct., as fixed on the 15th inst.

ANTE-WAR PRICES AND DIVIDENDS, LATEST DIVIDENDS, AND LAST WEEK'S TRANSACTIONS.

Issue.	Share.	When ex-Dividend.	Ante-War Dividend & Bonus.	Last Dividend.	NAME.	Closing Prices, July 30, 1914.	Present Prices.	Lowest and Highest Prices of Transactions.
£			p.c.					
182,049	Stk.	Mch. 15	4	4%	Aldershot 4 p.c. Pref.	..	70—75	...
1,551,868	,,	Apl. 12	2½	3 1/16%	Alliance & Dublin Ord.	59—64	62—67	...
374,000	,,	Jan. 12	4	4%	Do. 4 p.c. Deb.	76—79	62—67	...
280,000	5	May 18	7½	4/-	Bombay, Ltd.	5⅛—6⅛	4⅛—5	4⅛
100,000	5	Feb. 23	16	7½%	Bournemouth Gas and Water: 5 p.c.	..	10¼—11¼	...
383,110	10	,,	7	7%	Bournemouth Gas and Water: B 7 p.c.	15—15½	9—10	...
115,000	10	,,	6	6%	Bournemouth Gas and Water: Pref. 6 p.c.	13½—14	8—9	...
162,065	—	Dec. 30	—	4%	Bournemouth Gas and Water: 4 p.c. Deb.	..	65—70	...
992,045	Stk.	Feb. 9	14	56/-	Brentford A Consolid.	261—266	90—95	...
734,920	,,	,,	11	55/-	Do. B New	204—209	93—95	92½—93⅛
55,000	,,	,,	5	5%	Do. 5 p.c. Pref.	109—111	80—85	...
221,400	,,	June 15	4	4%	Do. 4 p.c. Deb.	91—93	73—78*	...
214,775	,,	Mch. 15	11	11½%	Brighton & Hove Orig.	208—213	165—170	...
244,200	,,	,,	8	8½%	Do. A Ord. Stk.	154—159	118—123	121—122
2,287,500	Stk.	July 28	5	5%	Bristol 5 p.c. max.	..	..	...
530,000	20	Mch. 15	12½	10%	British	44—45	29—31	...
120,000	Stk.	Dec. 30	4	4%	Do. 4 p.c. Deb. Stk.	88—90	78—82	...
245,771	,,	,,	4	4%	Buenos Aires 4 p.c. Deb.	85—87	55—60	...
100,000	10	June 1	—	7%	Cape Town & Dis., Ltd.	1½—2½	6½—7½	...
100,000	10	Apl. 27	—	4½%	Do. 4½ p.c. Pref.	4—6	6½—7½	...
100,000	Stk.	Dec. 30	4½	4½%	Do. 4½ p.c. Deb. Stk.	70—75	75—80	...
137,150	,,	Feb. 26	5	5%	Chester 5 p.c. Ord.	108—110	..	...
2,513,280	,,	Mch. 15	5/9/4	42/8	Commercial 4 p.c. Stk.	106—108	91—96	93¼—94
560,000	,,	,,	5½	38/4	Do. 3½ p.c. do.	103—105	92—97	93¼—93½
475,000	,,	June 15	3	3%	Do. 3 p.c. Deb. Stk.	69½—71½	55—60*	57
800,000	,,	Dec. 15	4	—	Continental Union, Ltd.	76—79	37—42	38⅛
200,000	,,	,,	7	—	Do. 7 p.c. Pref.	115—118	55—60	56
51,600	,,	Feb. 23	15	15%	Croydon A 10 p.c.	..	200—210	...
278,400	—	,,	12	12%	Croydon B and C 7 p.c.	..	160—170	150
492,270	Stk.	—	6	4½%	Derby Con. Stk.	123—125	80	...
55,000	,,	—	4	4%	Do. Deb. Stk.	102—104	65	...
1,002,180	10	Jan. 26	10	5/0	European, Ltd.	17½—18	12—13	...
26,298,975	Stk.	Feb. 23	4/17/4	46/8	Gas Light and Coke: 4 p.c. Ord.	98—102	96—99	96⅝—98
2,600,000	,,	,,	3½	35/-	Gas Light and Coke: 3½ p.c. max.	76—79	64—67	...
4,062,235	,,	,,	4	4%	Gas Light and Coke: 4 p.c. Con. Pref.	96—99	77—81	77—79
4,674,850	,,	June 15	3	3%	Gas Light and Coke: 3 p.c. Con. Deb.	72½—74½	61—64*	62½—64
130,000	,,	Dec. 11	10	10%	Gas Light and Coke: 10 p.c. Bonds	..	..	...
82,500	,,	Sept. 14	5	3½%	Hastings & St. L. 5 p.c.	..	..	...
258,740	,,	Mch. 15	3½	2⅜%	Do. 3½ p.c.	87—89	52—57	...
70,000	10	May 18	11	5%	Hongkong & China, Ltd.	16½—16¾	6—7	...
86,600	Stk.	Mch. 15	9	9½%	Hornsey 7 p.c.	..	115—120	...
131,000	,,	,,	7½	7½%	Ilford A and C	151—154	120—130	...
65,780	,,	,,	6½	5⅜%	Do. B.	115—118	100—110	...
65,500	,,	Dec. 30	4	4%	Do. 4 p.c. Deb.	92—94	75—80	...
2,976,000	,,	May 18	9	5%	Imperial Continental	150—160	162—167	162½—163½
404,800	,,	Feb. 9	3½	3½%	Do. 3½ p.c. Deb. Red.	84—86	75—80	74—78
235,242	,,	Mch. 15	6½	6½%	Lea Bridge Ord. 5 p.c.	119—121	83—88	...
2,498,905	,,	Feb. 26	10	37/6	Liverpool 5 p.c. Ord. A.	211—213	..	...
					Liverpool 5 p.c. Ord. B.	146—148	..	...
306,083	,,	June 26	4	4%	Do. 4 p.c. Pr. Deb. Stk.	..	..	...
165,736	,	Feb. 23	7/5/6	6%	Maidstone 5 p.c.	..	80—85	...
63,480	,,	Dec. 30	—	3%	Do. 3 p.c. Deb	..	48—51	...
75,000	5	June 11	6	3%	Malta & Mediterranean	4½—4¾	3½—3¾	...
250,000	100	Apl. 3	4½	4½%	Met. of Melbourne 4½ p.c. Deb.	99—101	91—98	...
541,920	Stk.	June 1	4	4%	Monte Video, Ltd.	11½—12	63—68	...
2,875,892	,,	Feb. 23	4½	4½%	Newcastle & Gatsh'dCon.	98½—99½	83½—84½	...
529,705	,,	Dec. 30	3½	3½%	Do. 3½ p.c. Deb.	82—83	69—71	...
15,000	10	Aug. 26	—	7/6	North Middlesex 10 p.c.	..	12½—13	...
33,940	10	Mch. 15	7/14/0	10/13	,, ,, 7 p.c.	14—15	10¼—11¼	11⅛
300,000	Stk.	May 18	8	8%	Oriental, Ltd.	117—122	90—95	...
60,000	5	—	10	—	Ottoman, Ltd.	7½—7¾	2—3	...
188,120	Stk.	Dec. 30	—	6%	Plym'th & Stonh'se 5 p.c.	..	95—100	...
60,000	50	Mch. 15	13	62/6	Portsea Island, B	128—131	87—90	...
100,000	50	,,	12	57/6	Do. C	118—121	78—83	...
249,980	5	—	8	—	Primitiva Ord.	5⅛—6	⅛—⅜	14/9—16/-
499,960	5	—	5	—	Do. 5 p.c. Pref.	4⅛—5	2—2½	40/—41/6
521,600	100	June 1	4	4%	Do. 4 p.c. Deb.	91—93	74—76	...
600,000	Stk.	Jan. 26	4	4%	Do. ,, ,, 1911	..	55—60	...
346,198	,,	Dec. 30	4	4%	River Plate 4 p.c. Deb.	85—87	55—60	57½
150,000	10	Mch. 30	6	6/-	San Paulo 6 p.c. Pref.	10¼—11	5½—6½	...
125,000	50	Jan. 3	5	5%	San Paulo 5 p.c. Deb.	47—49	36—39	...
135,000	Stk.	Mch. 15	10	5%	Sheffield A	223—224	89—92	...
209,984	,,	,,	10	5%	Do. B	222—224	89—92	...
523,500	,,	,,	10	5%	Do. C	220—222	89—92	...
133,201	Stk.	Sept. 15	4	4%	Shrewsbury 5 p.c.	..	..	...
90,000	10	Oct. 28	9	8%	South African	10⅛—11⅛	7—9	...
6,609,895	Stk.	Feb. 9	5/4/0	5%	South Met. Ord.	111—113	96—99	96½—97½
250,000	,,	Jan. 12	—	5%	Do. Red. Pref.	..	96—98	...
1,895,445	,,	,,	3	3%	Do. 3 p.c. Deb.	72½—74½	60—63	...
224,820	,,	Feb. 23	8½	8½%	South Shields Con. Stk.	157—159	106—108	...
2,087,795	,,	,,	6	5½%	S'th Suburb'n Ord. 5 p.c.	114—116	98—103	100¼—100⅜
368,837	,,	June 15	5	5%	Do. 5 p.c. Deb. Stk.	116—118	93—98*	95
647,740	,,	May 18	5	5%	Southampton Ord.	99—102	70—75	...
121,275	,,	Dec. 30	4	4%	Do. 4 p.c. Deb. Stk.	..	65—70	...
120,000	,,	Feb. 23	—	7½%	Tottenham and District: A 5 p.c.	135—138	112—117	...
782,275	,,	,,	6	5½%	Tottenham and District: B 3½ p.c.	115—117	98—103	...
181,255	,,	June 15	4	4%	Tottenham and District: 4 p.c. Deb.	87—89	75—80*	...
182,380	10	Dec. 30	5	—	Tuscan, Ltd.	5—6	1—2	...
149,900	10	July 1	5	5%	Do. 5 p.c. Deb. Red.	93—95	45—50	...
230,476	Stk.	Mch. 15	5	3½%	Tynemouth 5 p.c. max.	108½—109	71—73	...
					Wandsworth, Wimbledon, and Epsom—			
30,000	,,	Mch. 15	8½	66/3	Wandsworth A 5 p.c.	151—156	110—115	...
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Gas Prices in Scotland.—The Falkirk Town Council have reduced the price of gas 1s. for lighting and domestic purposes, and 1s. 3d. for power and industrial purposes, making the prices 4s. 9d. and 4s. per c.ft. respectively. Dunbar has reduced the rate for gas 10d., bringing the price down to 6s. 3d.

Rugby Gas Company.—Messrs. A. & W. Richards inform us that the tenders sent in for the £25,000 of 6 p.ct. redeemable preference stock which they offered for the Rugby Gas Company amounted to £72,150, and ranged from £105 down to the minimum of £97. The lowest price to secure an allotment was £98 per £100; and the average price at which the issue went was £99 11s. p.ct., yielding to the investor £6 1s. 4d. p.ct.

A New Holder for Padiham.—The Padiham District Council have decided to apply for sanction to borrow £6500 for the erection of a spiral gasholder and steel tank. They have accepted the tender of Messrs. R. & J. Dempster, Ltd., to erect the holder and tank for £4820, on foundations to be prepared by the Council. The Chairman of the Gas Committee said the work had been delayed by the Council owing to the high cost; but they were now hoping to be ready for the holder early in July.

Reduction in Price at Clitheroe.—The Clitheroe Town Council last Tuesday week decided to reduce the price of gas by 4d. per 1000 c.ft. Alderman W. W. Whiteside, Chairman of the Gas Committee, stated they had passed through a year of anxiety very well. The coal stoppage alone cost them something like £2800; while the income from residuals dropped £1525, compared with the previous year. Last Christmas gas was reduced 6d. per 1000 c.ft. The total receipts for gas sold were £31,606, against an expenditure of £31,801, there being a deficit on the year's working of £195. An increased gas consumption of 7 million c.ft. had helped to keep the undertaking in a good position.

It is proposed by the Town Council to erect gas-works at Portsoy. At present the lighting is by acetylene gas, but coal gas is preferred.

At Ossett last week, Wilfred Waring was fined £5 for stealing money from gas-meters at Horbury. He had represented himself to be a gas-meter examiner and collector for the Ossett Corporation Gas Department. By means of a pin, he had taken 28s. 6d. from meters in three houses.

Tests are being made of the lighting of Princes Street, Edinburgh, by gas and electricity. The Gas Department have made an offer to provide candle power as cheap or cheaper than the Electricity Department. The Gas Engineer favours high-pressure gas-lamps of 3000 candle power.

A Liverpool man and his sister, Weston and Edith Brassington, largely owe their lives, states a local paper, to the presence of mind and initiative displayed by two employees of the Liverpool Gas Company. In response to a telephonic communication that there was a strong smell of gas near the house where the Brassingtons live, the Gas Company promptly dispatched two men to the house. One of the workmen knocked at the door, but received no reply. Upon pushing back the flap of the letter-box, his companion detected gas, and an entrance was effected from the back of the house. Mr. Brassington was found lying unconscious on a bed in one of the upstairs rooms; and notwithstanding the fumes, the Gas Company's employees managed to carry him downstairs. Mr. Brassington's sister was afterwards discovered in another bedroom, also lying on a bed unconscious. The unconscious couple were removed to the Infirmary, where hopes were entertained of their recovery. Gas was found to be escaping from a pipe under the road in the vicinity of the house.

The Launceston Gas Company announce that the price of gas at Launceston will be reduced by 5d. per 1000 c.ft.

Messrs. Walter Judd, Ltd., ask us to announce that their new address is 81-87, Gresham Street, London, E.C.2.

At Lanark, a showroom is to be opened to aid the sale of gas; and cookers and other appliances are to be supplied to consumers. Other developments include the laying of new gas-mains.

At the South London Cyclists' Carnival, held at the Crystal Palace on Saturday last, Miss M. Lidbetter secured the second prize in the Ladies' Advertisement Costume Section, with a very excellent representation of last season's "Volker" gas-mantle poster.

Messrs. A. & W. Richards are offering, by order of the Directors, for sale by tender £5000 of 7 p.ct. redeemable preference stock (or such amount as will with premiums realize this net sum) in the Crowborough District Gas Company. The minimum price of issue is par; and the stock is to be redeemed at par on Dec. 31, 1930. The issue is rendered necessary by the increasing demands for gas.

Mr. W. P. Ford, foreman of fitters, was on Monday the recipient at the Plymouth Gas-Works of an inscribed pair of binoculars, on the occasion of his retirement from the service of the Gas Company, after completing 59 years' service. In making the presentation on behalf of Mr. Ford's fellow workmen, Mr. P. S. Hoyte (the Engineer) said the Directors had made provision so that Mr. Ford might be able to enjoy his well-earned retirement. Mr. Ford, in his reply, remarked that he was 76 years of age.

Last Saturday week, the Windsor Gas-Works, which adjoin the Great Western Railway Station, had a narrow escape from destruction by fire, which broke out in one of the Windsor branch line arches. So fierce were the flames on the gas-works side of the line, that they almost spread to one of the holders close at hand. It was a critical situation, as the flames were fanned by a strong breeze, and the Engineer (Mr. H. Buckley) started immediately to transfer the gas to another holder. The flames were, however, quelled before the real danger was reached.

It was little thought nine years ago, when the Directors of the Davis Gas-Stove Company, Ltd., laid a bowling green of Cumberland turf on a piece of land adjoining the works at Luton, that they would be the hosts on the occasion of the visit of the Australian Bowling Team to England to play Herts and Beds among other teams up and down the country. Friday, June 16, was the occasion of this signal honour; and as the Davis Company were among the pioneers of the game in the county of Bedfordshire, it was perhaps fitting that their green should be selected (being the finest in the county, and considered by many international bowlers to be one of the best in the country) for this important match—Herts and Beds *v.* Australians. On arrival in Luton the Australian contingent were conveyed in motor vehicles to the Davis works, where luncheon was served. Mr. H. N. Davis presided, supported by the Mayors of Luton, Dunstable, and Bedford, and other prominent townsmen and representative people in the bowling world. On behalf of the Davis Club (of which Mr. H. N. Davis is the President), the Chairman extended a hearty welcome to the teams. In the bowling match which followed, the Australians left nothing to chance. They played well to a man, and completely reversed the bad fortune which had been their lot in seven consecutive matches. The Beds and Herts bowlers sustained a very heavy defeat, by 156 points to 95 points. The home players lost at every rink; but it is significant that at the Bedfordshire rink, when defeat was sustained by only one point, three of the home players were Davis Club men, which indicates that the Club possesses some very fine bowlers. Immediately after the match, the teams and the officials were entertained at dinner by the Davis Company—Mr. H. N. Davis presiding.

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REPRESENTATIVES required to Sell High-Grade Incandescent BURNERS, LAMPS, &c., on Commission. Good Connection essential.
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BEDS of 6's and 8's 22 by 15 ○ 6 in. Pipes. Cheap before removal. Could refix or Tender including Retorts and Settings.
GASHOLDERS—300,000, 172,000, 50,000, 40,000, and Two 5000 capacity.
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CONDENSERS. Sets of 4 Annular, 8 in. & 12 in. Connections. Sets of 6 in. & 9 in. Vertical Pipes. Water Tube Condenser 15 in. Connections.
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FOR SALE, at a reasonable price, COMPLETE COAL-GAS PLANT to Manufacture 350,000 c.ft. per twenty-four hours, including Four Gasholders of respective capacities of 106,000, 94,000, 50,000 and 46,000 c.ft.; Complete WATER-GAS PLANT to Generate 500,000 c.ft. per twenty-four hours, with Relief Holder, Boilers, &c.
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SEDGLEY URBAN DISTRICT COUNCIL.
(GAS DEPARTMENT.)

TENDERS are invited for the Supply and Delivery of about 1500 Tons of GAS COAL or NUTS, to the Shutt End Siding, Brettel Lane Station (G.W. Railway), during the Three Months ending Sept. 30 next.

Sealed Tenders, endorsed "Coal," should reach the undersigned, from whom all Particulars may be obtained, not later than 5th July.

The Council reserve the right to apportion the above quantity to more than one contractor, and do not bind themselves to accept the lowest or any Tender.

JOSEPH BRETTLE,
Engineer and Manager.

Gas-Works,
Lower Gornal,
near Dudley.

COVENTRY CORPORATION.
(GAS DEPARTMENT.)

TENDERS FOR GAS COAL.

TENDERS are invited for Supply of GAS COAL for Twelve Months commencing the 1st of August next.

Form of Tender and full Particulars may be obtained on application to the undersigned.

P. N. LANGFORD,
General Manager.

June 22, 1922.

MANCHESTER CORPORATION.
(GAS DEPARTMENT.)

THE Gas Committee are prepared to receive TENDERS for the Work required to be done in the TARRING of ROOF PRINCIPALS, STANDARDS, &c., at their Rochdale Road Gas-Works.

Specification and Form of Tender may be obtained on application to Mr. Godfrey W. Kaye, Secretary, Gas Department, Town Hall, Manchester.

The Drawing of the Roof may be seen, and permission to inspect the work obtained, together with any other Information required, on Application to the Engineer, at his Office, Rochdale Road Gas-Works, Manchester.

Sealed Tenders, addressed to the Chairman of the Gas Committee and endorsed "Tarring of Retort-House Roof Principals, &c., Rochdale Road Gas-Works," must be Delivered at the Gas Office, Town Hall, Manchester, not later than 5 p.m. on Thursday, the 13th of July, 1922.

The Committee do not bind themselves to accept the lowest or any Tender.

By order,
P. M. HEATH,
Town Clerk.

Town Hall,
Manchester,
June, 1922.

ROBERT DEMPSTER & SONS, Ltd., ELLAND, Builders of CARBONIZING PLANTS, both Horizontal and Vertical. Manufacturers of CONDENSERS, PURIFIERS, GASHOLDERS, &c., also every description of COAL and COKE HANDLING PLANT. Telegrams: "DEMPSTER, ELLAND." Telephone ELLAND 261 (Private Branch Exchange).

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PENRITH URBAN DISTRICT COUNCIL.

TAR.

THE Gas Committee of the above Council are prepared to consider TENDERS for the Purchase of the SURPLUS TAR produced at their works during the Year ending June 30, 1923.

Tenders, endorsed "Tender for Tar," must be Delivered to Mr. Geo. Wainwright, Clerk, Town Hall, Penrith, not later than noon on Monday, July 10, 1922.

The Committee do not bind themselves to accept the highest or any Tender.

Further information may be obtained from
E. SHAUL,
Manager.

Gas-Works,
Penrith,
June 23, 1922.

TIPTON URBAN DISTRICT COUNCIL.

(GAS DEPARTMENT.)

THE Gas Committee of the above Department invite TENDERS for an Installation of VERTICAL RETORTS, capacity 750,000 c.ft. per day.

Further particulars may be had from the Engineer at the Gas-Works.

Tenders to be sent in by July 10, 1922, and to be endorsed "Tender for Vertical Retorts" and addressed Chairman of the Gas Committee, Alexandra Road, Tipton.

The Council do not bind themselves to accept the lowest or any Tender.

By order,
WILLIAM PRINCE,
Engineer and Manager.

COMPANY NOTICES.

COMMERCIAL GAS COMPANY.

NOTICE is Hereby Given that the TRANSFER BOOKS of this Company, SO FAR AS THEY RELATE TO CAPITAL STOCKS, WILL BE CLOSED from the 6th of July to the 5th of August, both days inclusive, and that Dividends in respect of the half year ending 30th of June, 1922, will be paid on the 15th of August next to the holders of Stock registered at the date of the closing.

By order of the Board,
F. J. BRADFIELD,
Secretary.

Offices: Stepney, E. 1,
June 15, 1922.

Demy 4to. Limp Cloth. Price 10s. 6d.

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One	30 0	× 9 3	× 150	5761.
Eleven	30 0	× 9 3	× 160	5749/53 & 5924/9.
Three	30 0	× 9 3	× 120	6019/20 & 6027.
Three	30 0	× 8 6	× 120	6017/8 & 6026.
One	30 0	× 8 3	× 175	5984.
Two	30 0	× 8 3	× 160	6028/9.
One	30 0	× 8 3	× 120	6025.
Four	30 0	× 8 3	× 100	5678.
One	30 0	× 7 6	× 180	5967.
Three	28 0	× 7 6	× 160	5792/4.

All the above Boilers are built from "Siemens Martin" Acid Steel.

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THE MAXIM PATENT CARBURETTOR.

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When a Crack develops in your Boiler—

when the retort mouthpieces get broken—when the coke discharge boxes receive damage—when the plug valve bodies develop a crack—when any of the hundred-and-one accidents which are likely to beset you and make a full gas service difficult—let the

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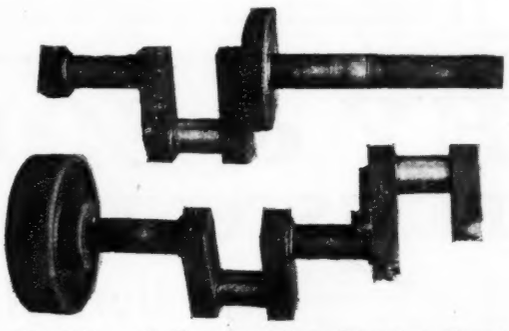

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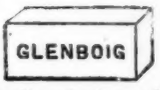
TRADE 

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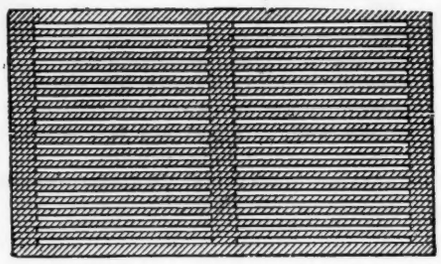

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WE FILL THE RETORT BY A SIMPLE MECHANISM WHICH

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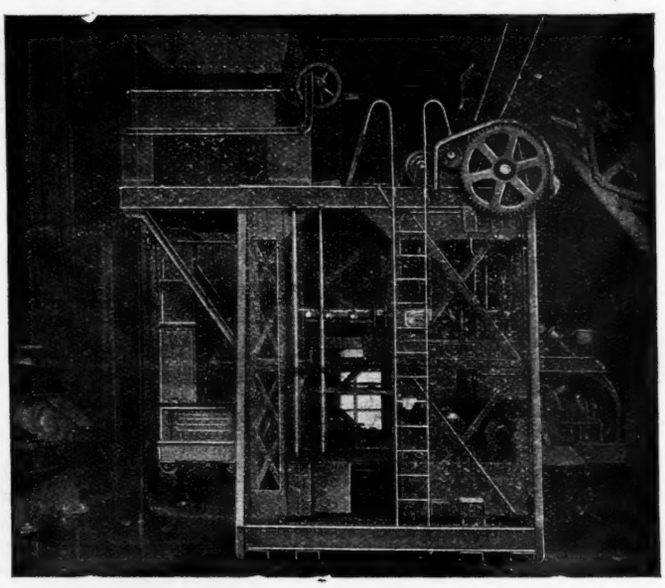

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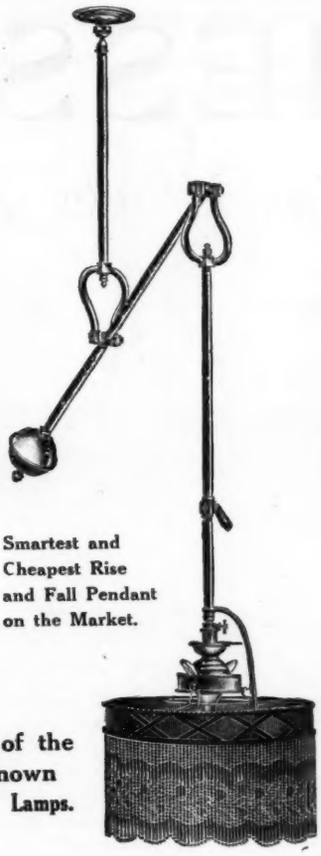

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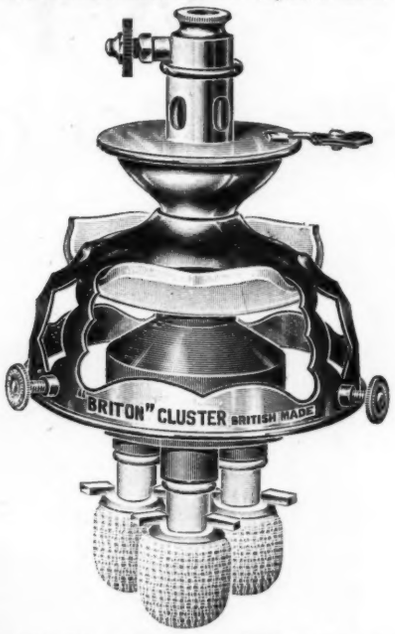

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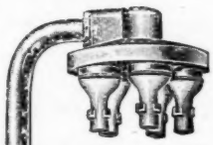

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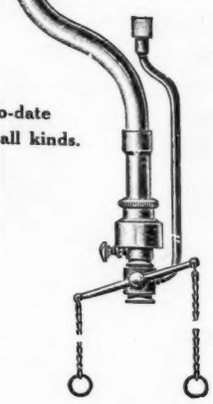

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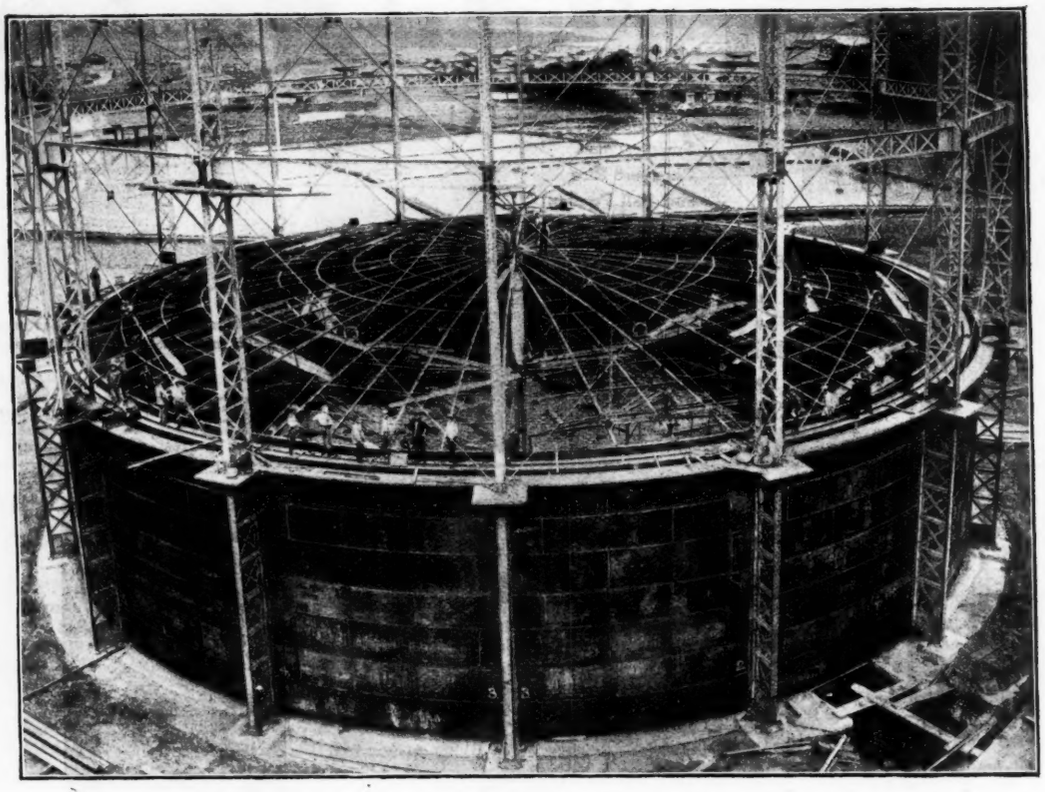

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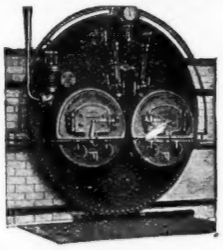

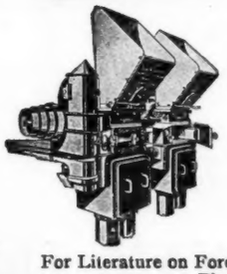

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Fitted with

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Heavy Cast-Brass Pre-Heated Inverted Burner.

With SINGLE OUTSIDE GAS and AIR REGULATOR.

Burner can be removed in situ.

PRE-HEATED BURNERS

Constructed of Cast Brass and Solid Drawn Tube.

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Fig. 2017.

Fig. 2071.

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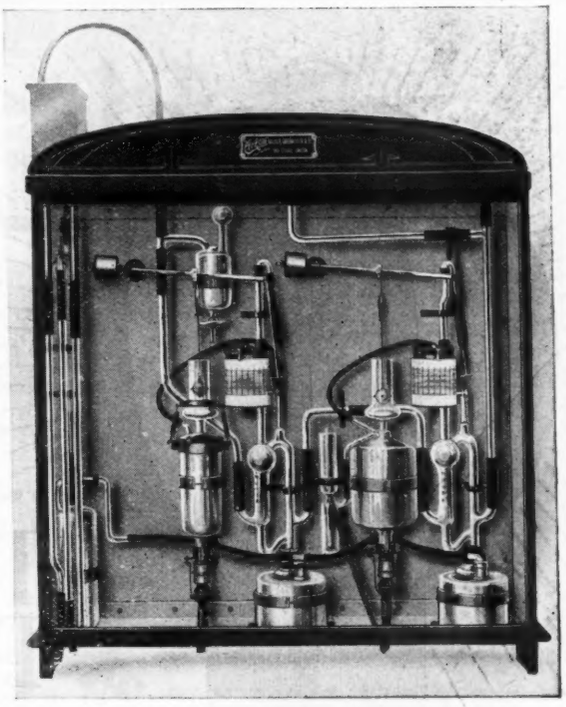

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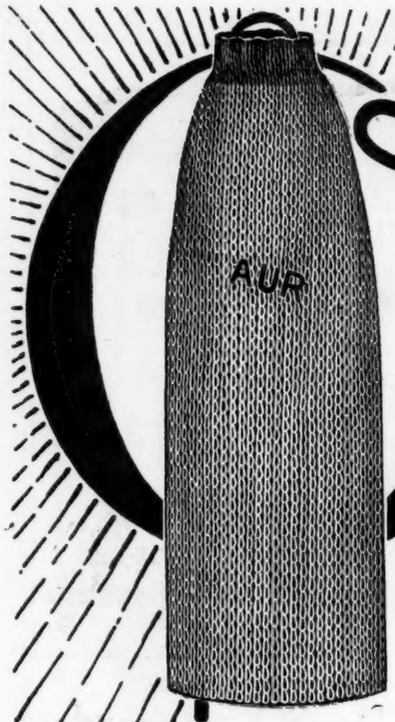

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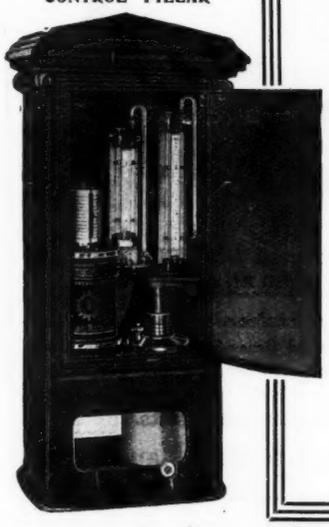

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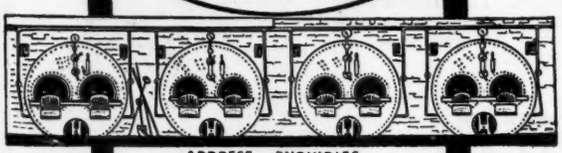

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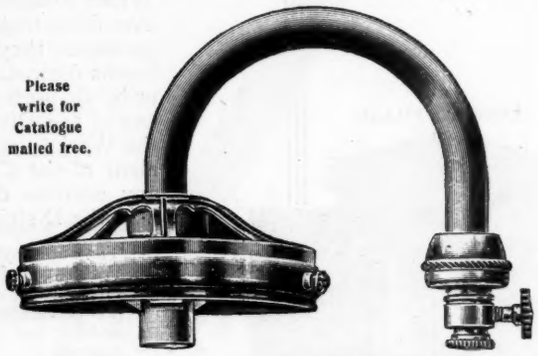

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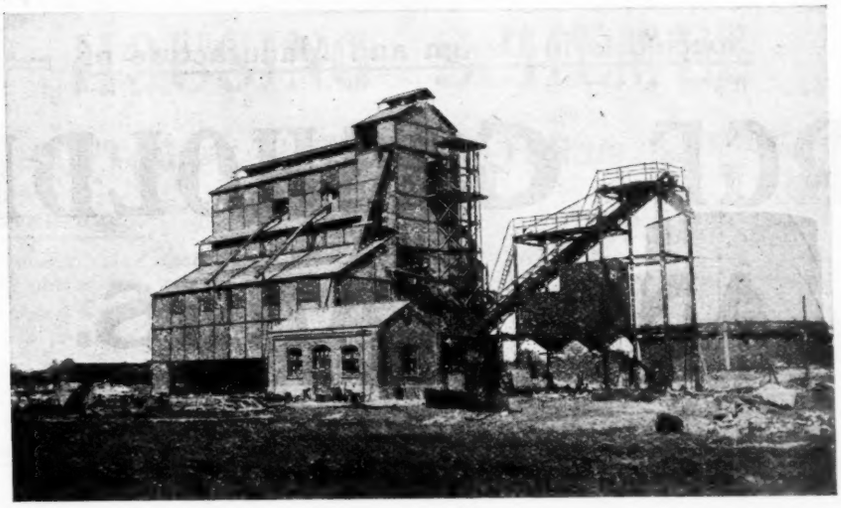

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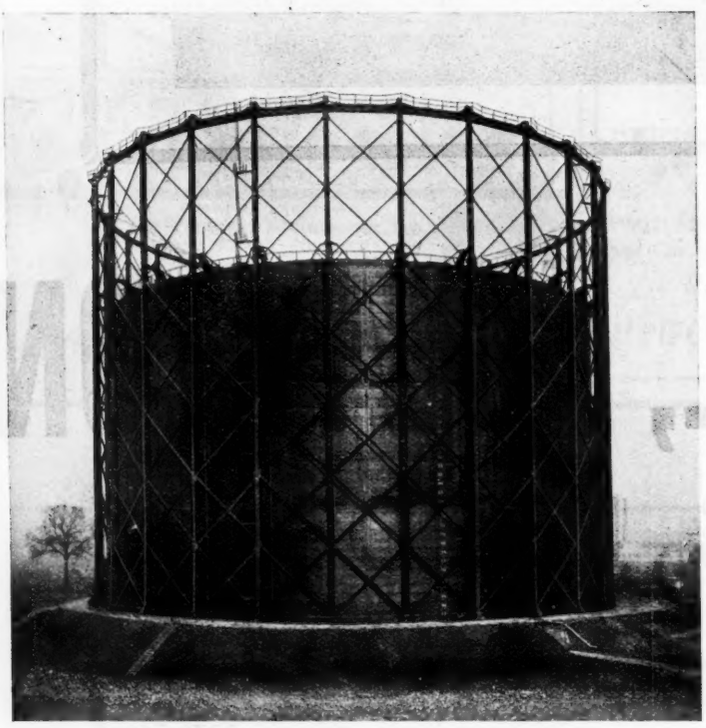

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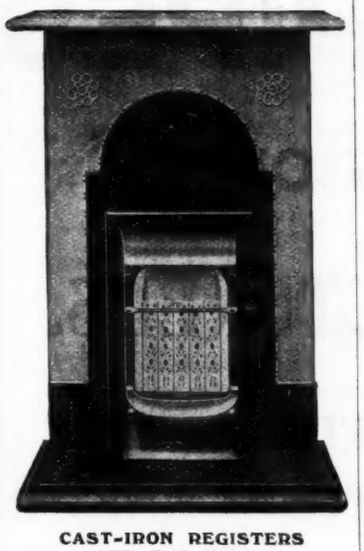

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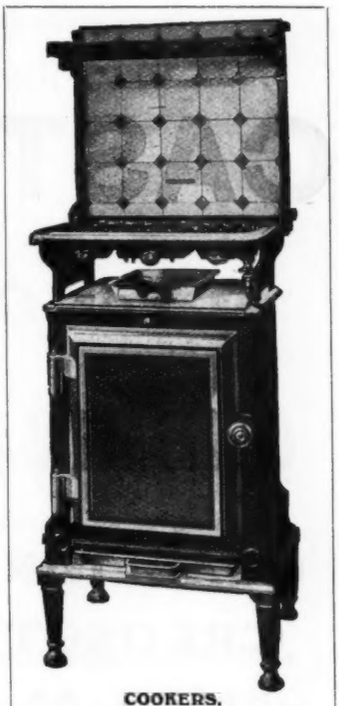

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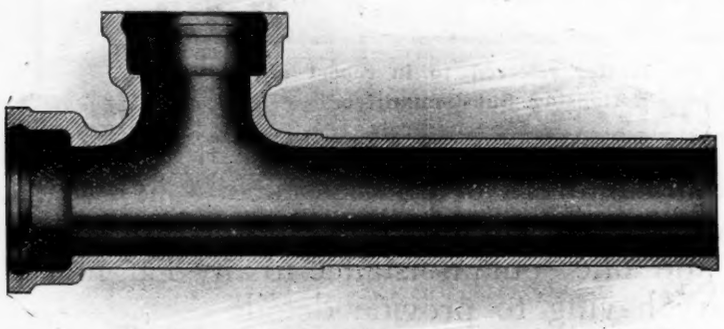

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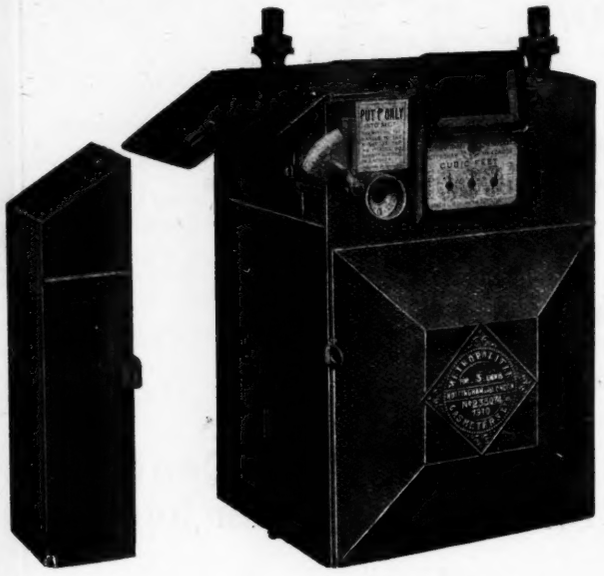

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Guaranteed to give gas-way to the FULL capacity of Meter (open outlet) with first coin.

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It reduces the consumption of gas very considerably.

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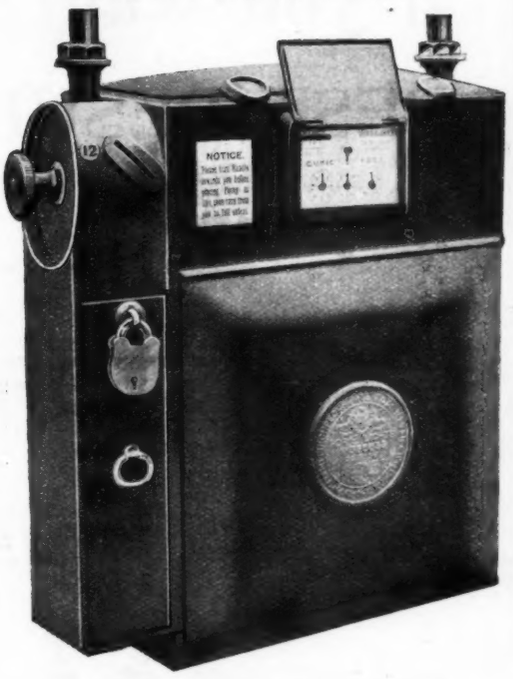

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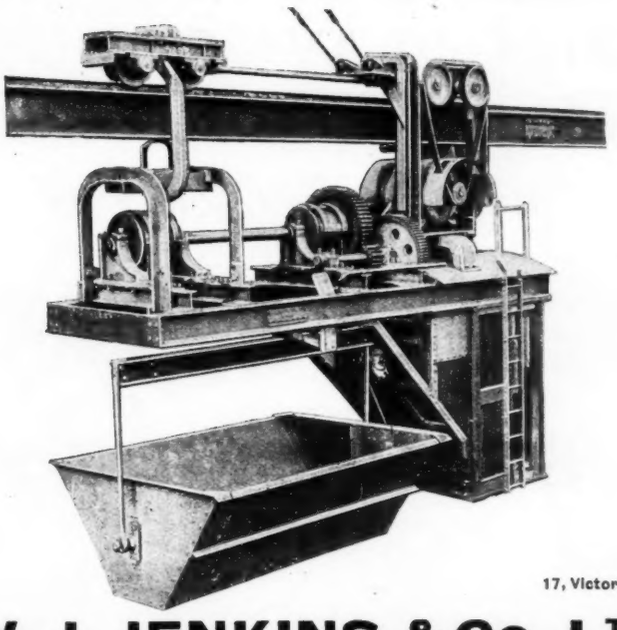

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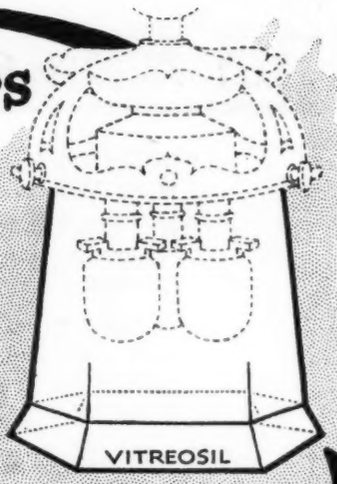

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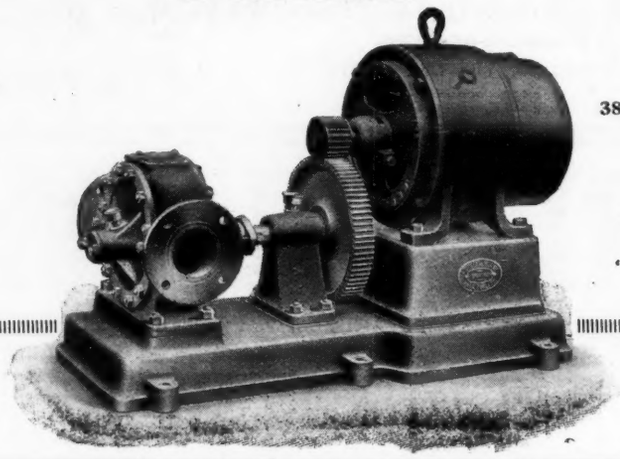

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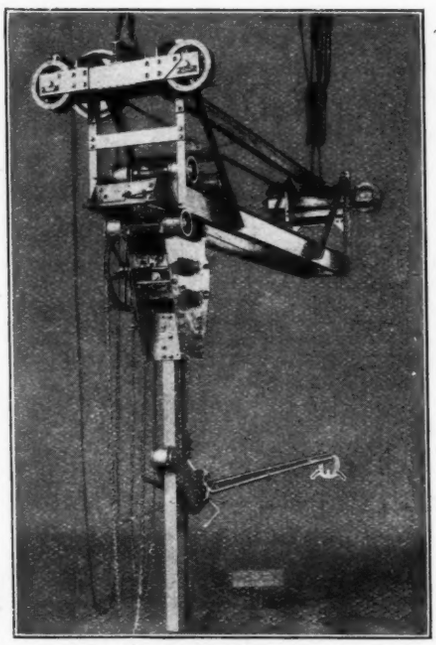

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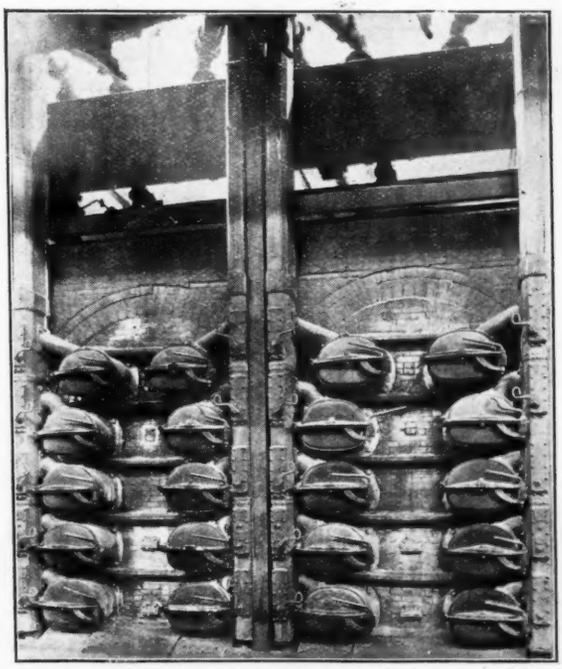

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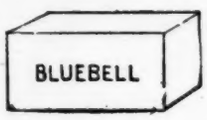

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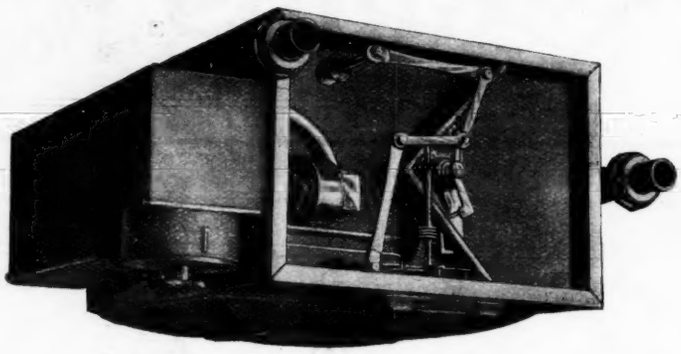

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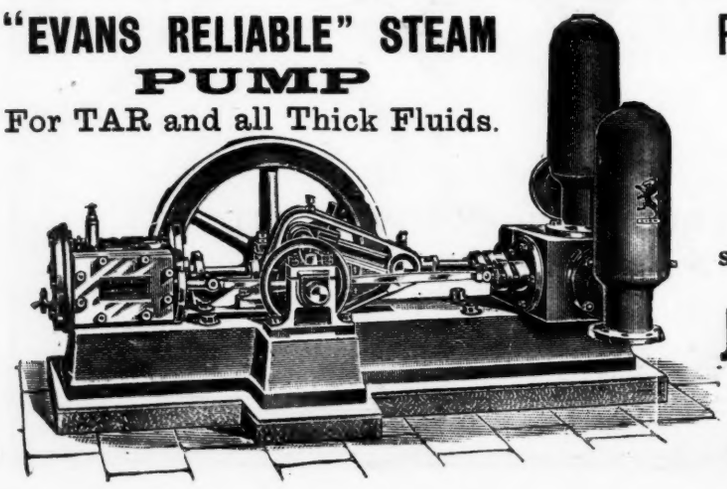

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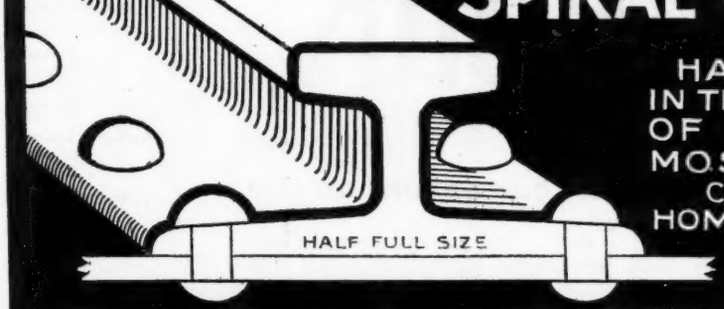

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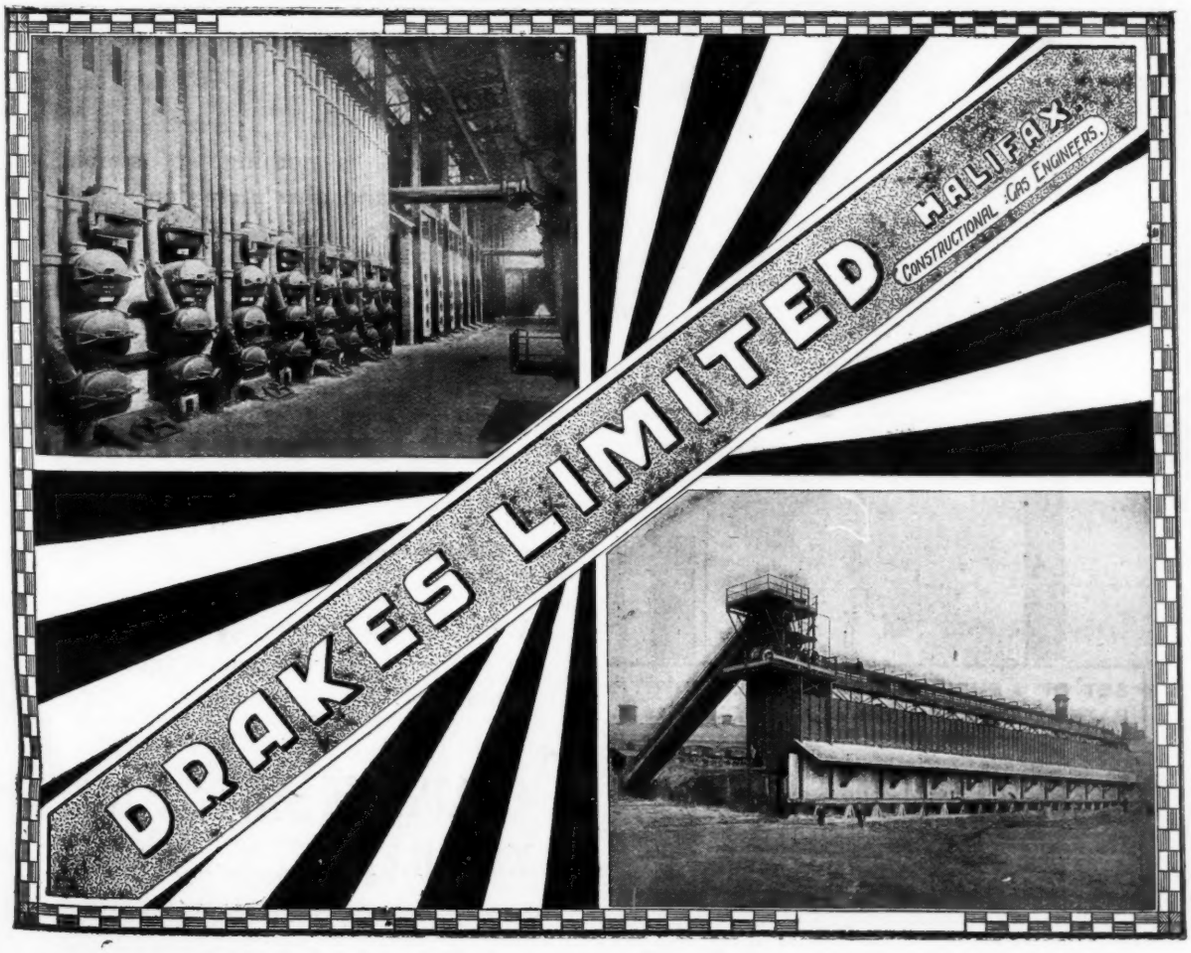

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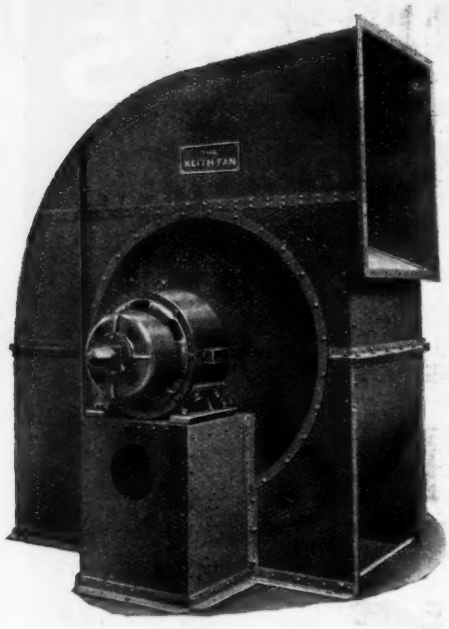

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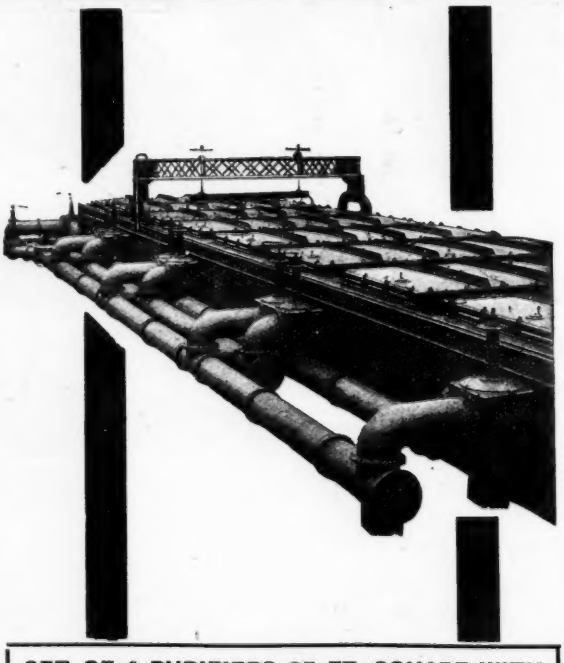

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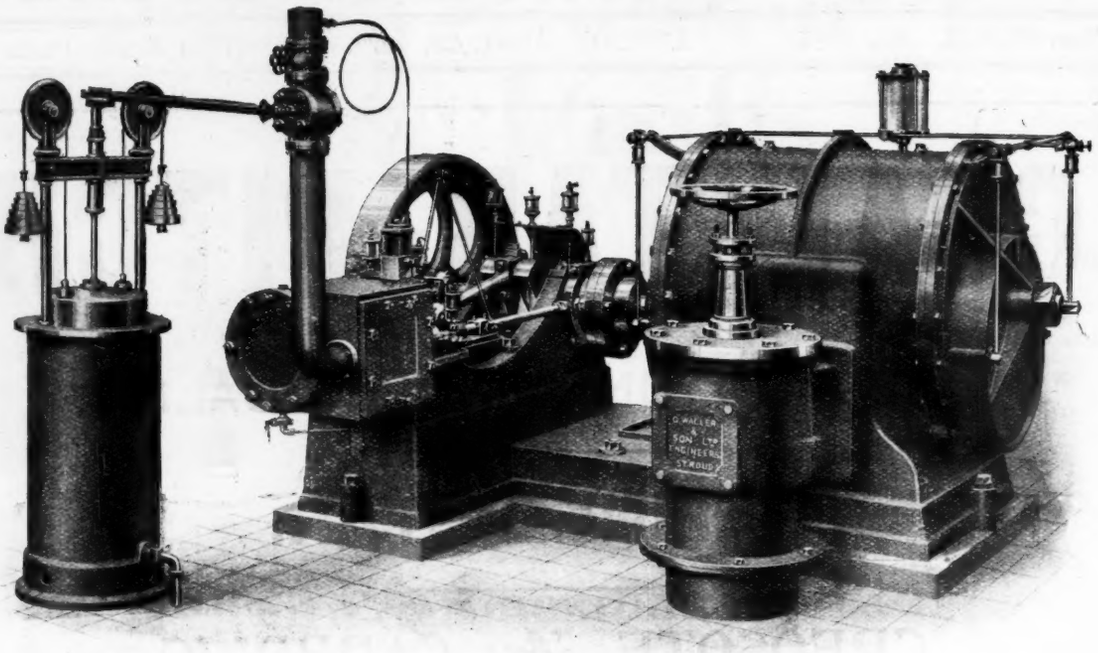

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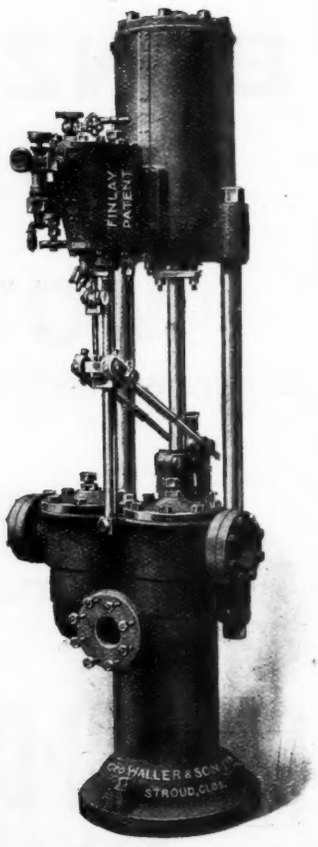

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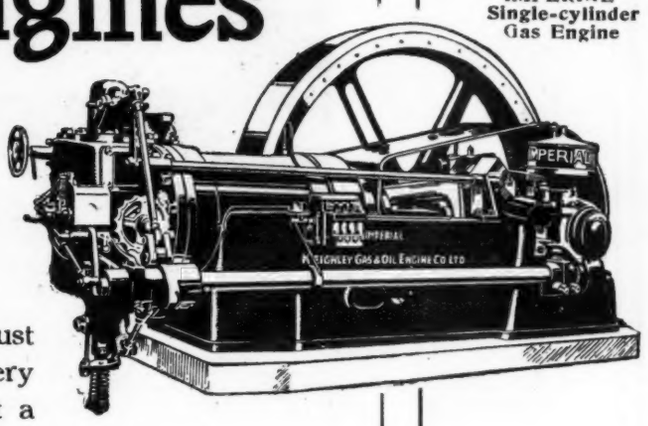

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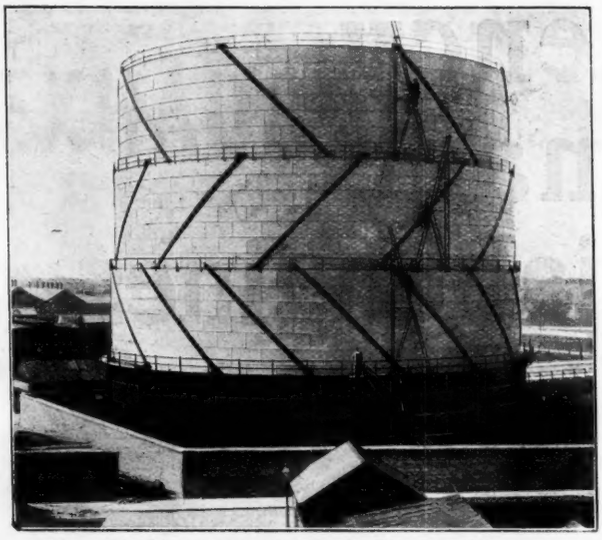

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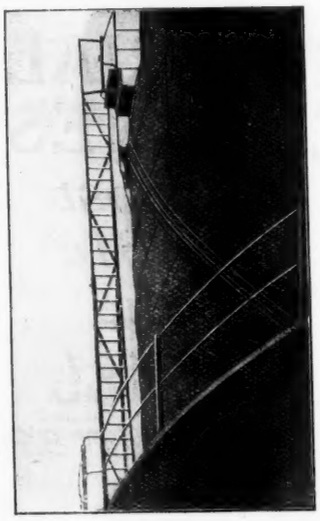

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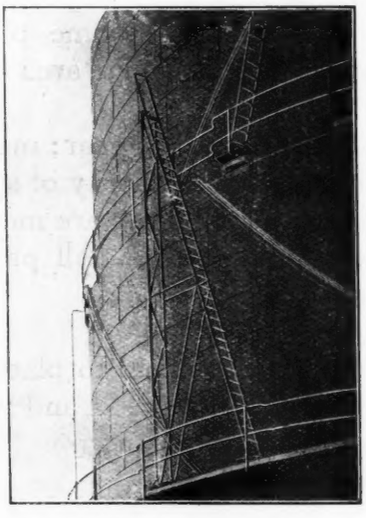

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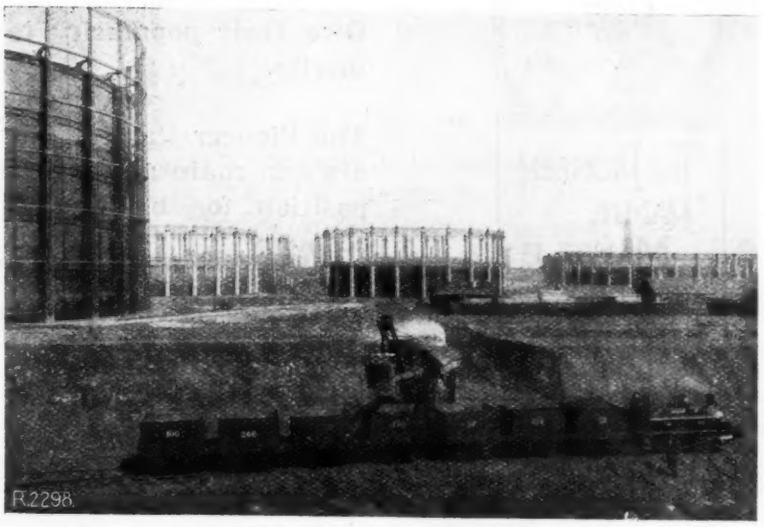

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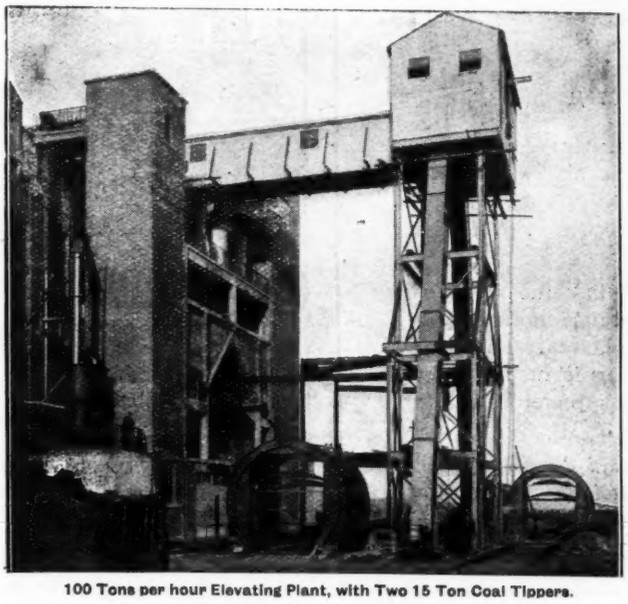

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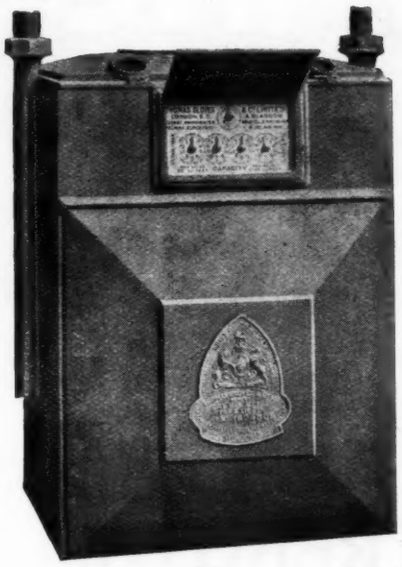

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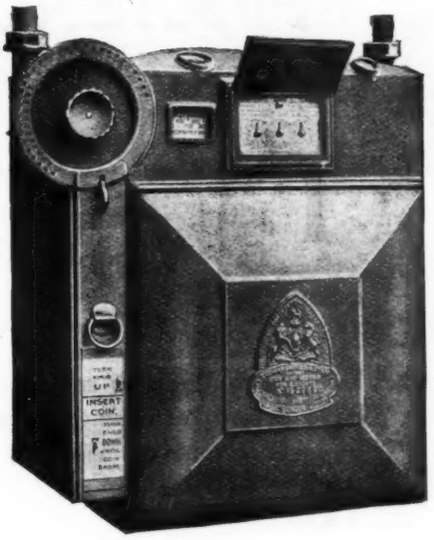

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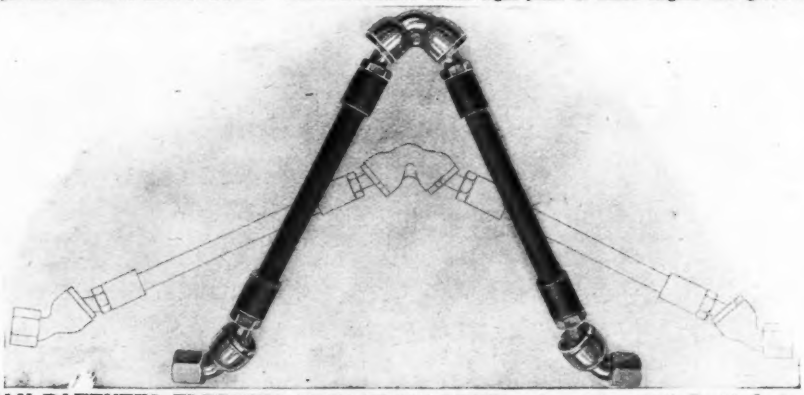

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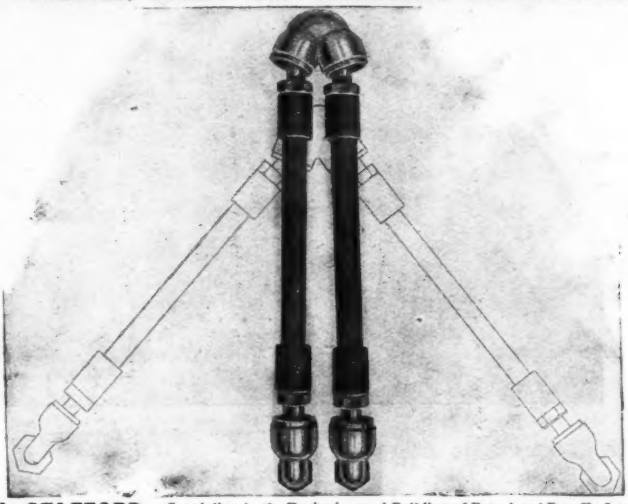

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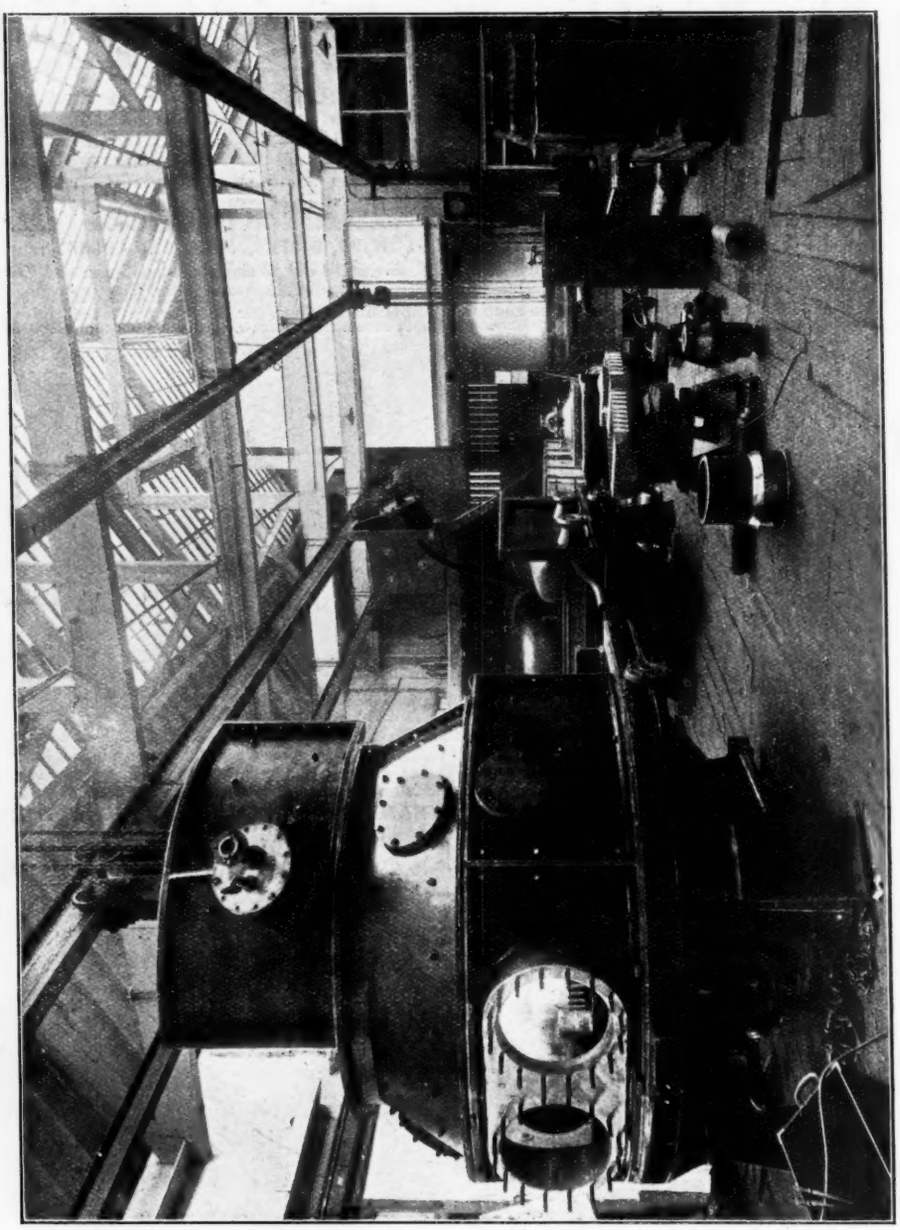


Telephone: BOLTON 848.

Telegrams: "SATURATORS, BOLTON."

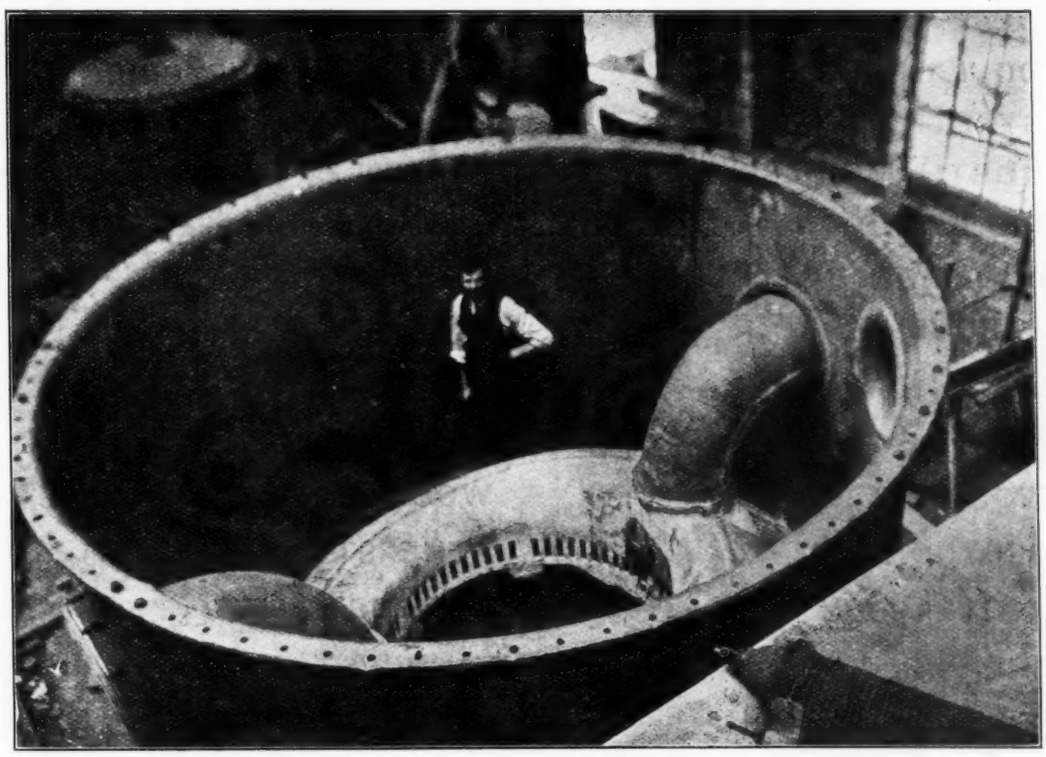
OVER 670 SATURATORS SUPPLIED.

THE KEYSTONE OF A SUCCESSFUL SULPHATE OF AMMONIA PLANT IS A RELIABLE SATURATOR.

ANY DESIGN FOR ANY PROCESS
MADE IN ANY THICKNESS OF LEAD.

DRAINING TABLES, ACID TANKS, AND ALL LEADWORK.

REPAIRS A SPECIALITY.



FROM A PHOTOGRAPH SHOWING SATURATOR IN MAKING.

JOSEPH TAYLOR (SATURATORS) Ltd.

CHEMICAL PLANT ENGINEERS,

BLACKHORSE STREET MILLS, BOLTON.

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THE "SYDENHAM" FURNACE GRATE.

In use or on order for following works :—

SOUTH SUBURBAN GAS LIGHT & COKE
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HARPENDEN
DEAL
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NORTH MIDDLESEX
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BUDLEIGH SALTERTON
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DOVER (Repeat)
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CROYDON
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NO CLINKERING
NO FALSE BARS
NO STEAM
REGULAR HEATS

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Vertical Gas Retort Syndicate, LTD.,
17, VICTORIA STREET,
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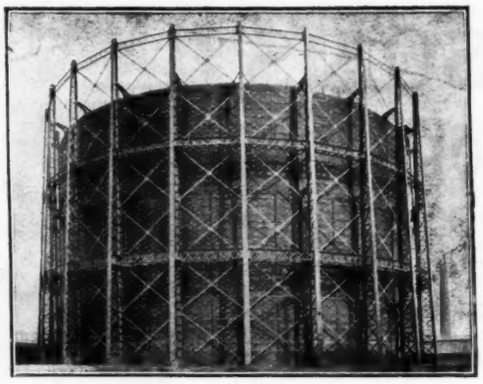
Telegraphic Address - "VERTIGARET, VIC., LONDON."



GASHOLDERS and TANKS
of any size or type.

CONDENSERS—Water Tube,
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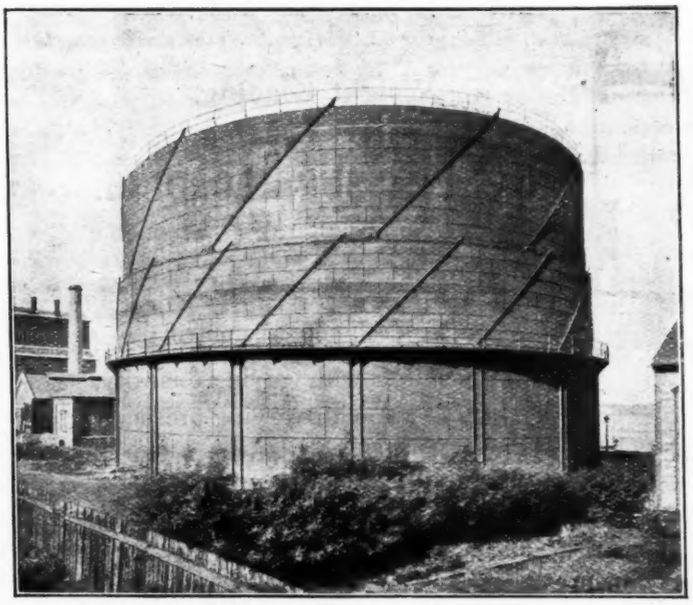

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STRUCTURAL WORK of every
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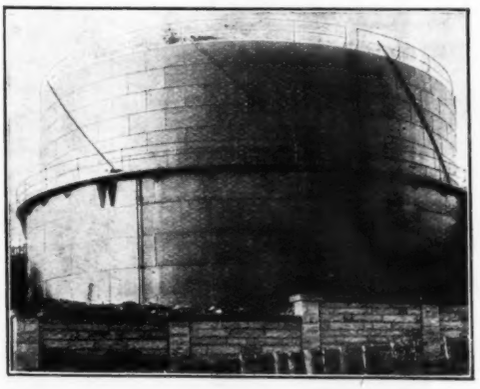

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GAS ENGINEERS AND CONTRACTORS,
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GLASGOW.
London Office: 6, LITTLE BUSH LANE, CANNON STREET, E.C. 2.

PARKINSON'S

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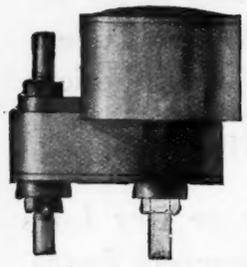
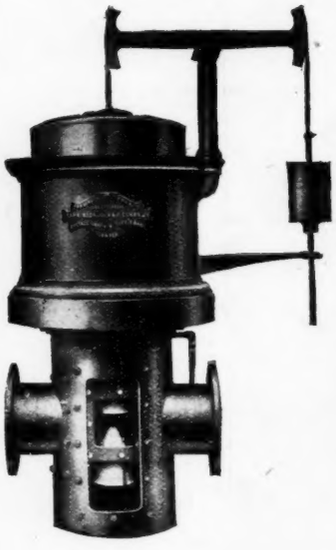
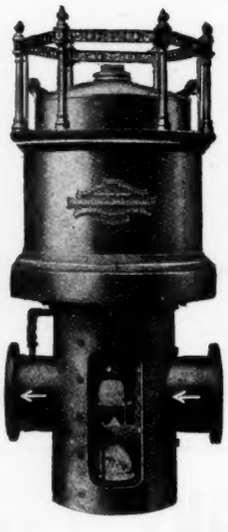


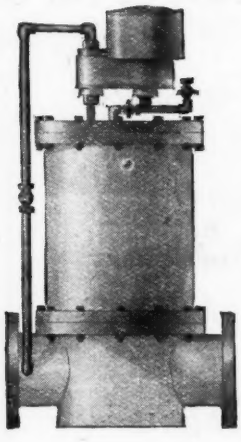
Station Governors,
District Governors,
HIGH PRESSURE GOVERNORS,
Consumers' Governors.

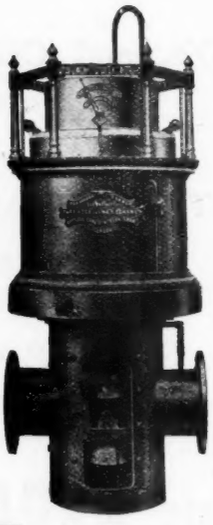


Weight Loading,
Water Loading,
GAS PRESSURE LOADING.

Can be designed to control:—
PRESSURE with varying quantity,
QUANTITY with varying pressure,
PROPORTION with varying quantity and pressure.







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Gas Yields. From 84 therms per ton of 450/500 B.Th.U. per c. ft. qualities guaranteed on plants of any size, according to coal given, combined with high coke and by-product yields.

Lowest initial and operating costs.
Appreciable coal and labour saving.
Space economy—long life.

Low Repair and Maintenance Charges.
Steaming at highest superheat and decomposition efficiency.

Continuous Vertical Multi-staged externally-internally heated Retorts essentially and fully embodying in simple, practical form all requirements of Scientific Carbonisation. All factors make for a smooth, efficient process for realising optimum and best quality products. Orderly and complete manipulation of the processes and mechanism of the retort operations.

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Telephone - VICTORIA 7569.

GAS EXHAUSTING PLANT.

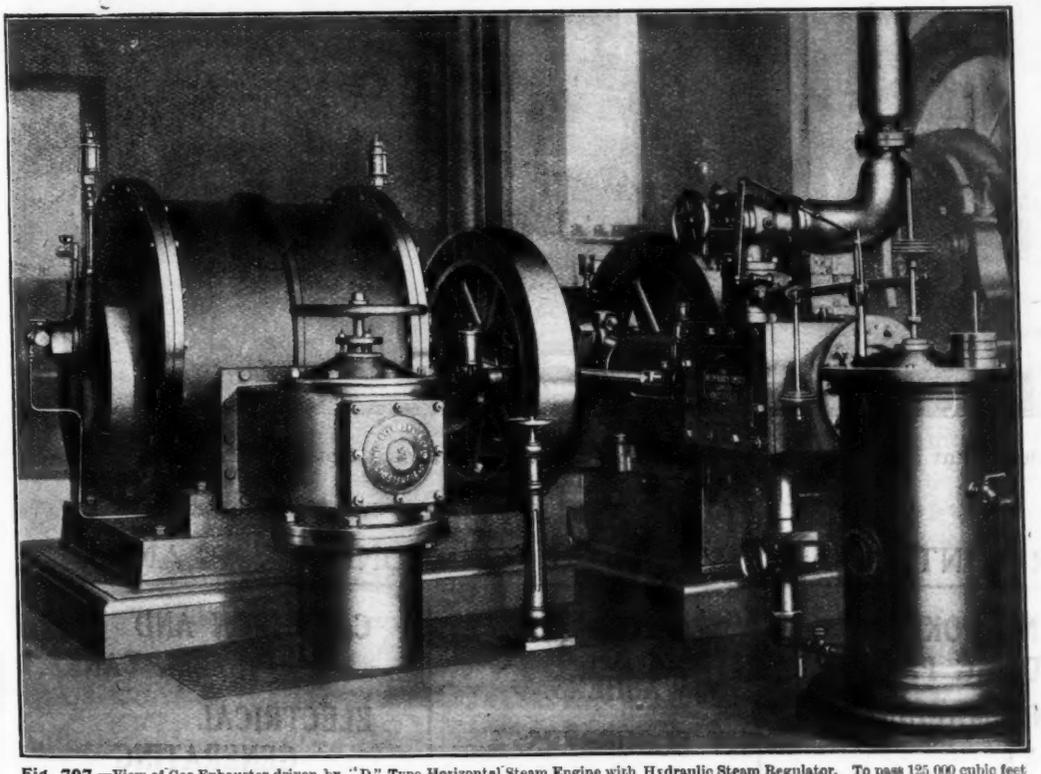

Fig. 707.—View of Gas Exhauster driven by "D" Type Horizontal Steam Engine with Hydraulic Steam Regulator. To pass 125,000 cubic feet per hour at 85 revs. per minute—70 lbs. Steam Pressure—against 36 in. pressure and 4 in. vacuum.

Valves of all types and sizes.

Oil Spraying Plants to prevent Naphthalene Troubles.

THE BRYAN DONKIN COMPANY, LTD.,

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ENGINEERS AND IRONFOUNDERS,

DRAKES LIMITED

GAS ENGINEERS,

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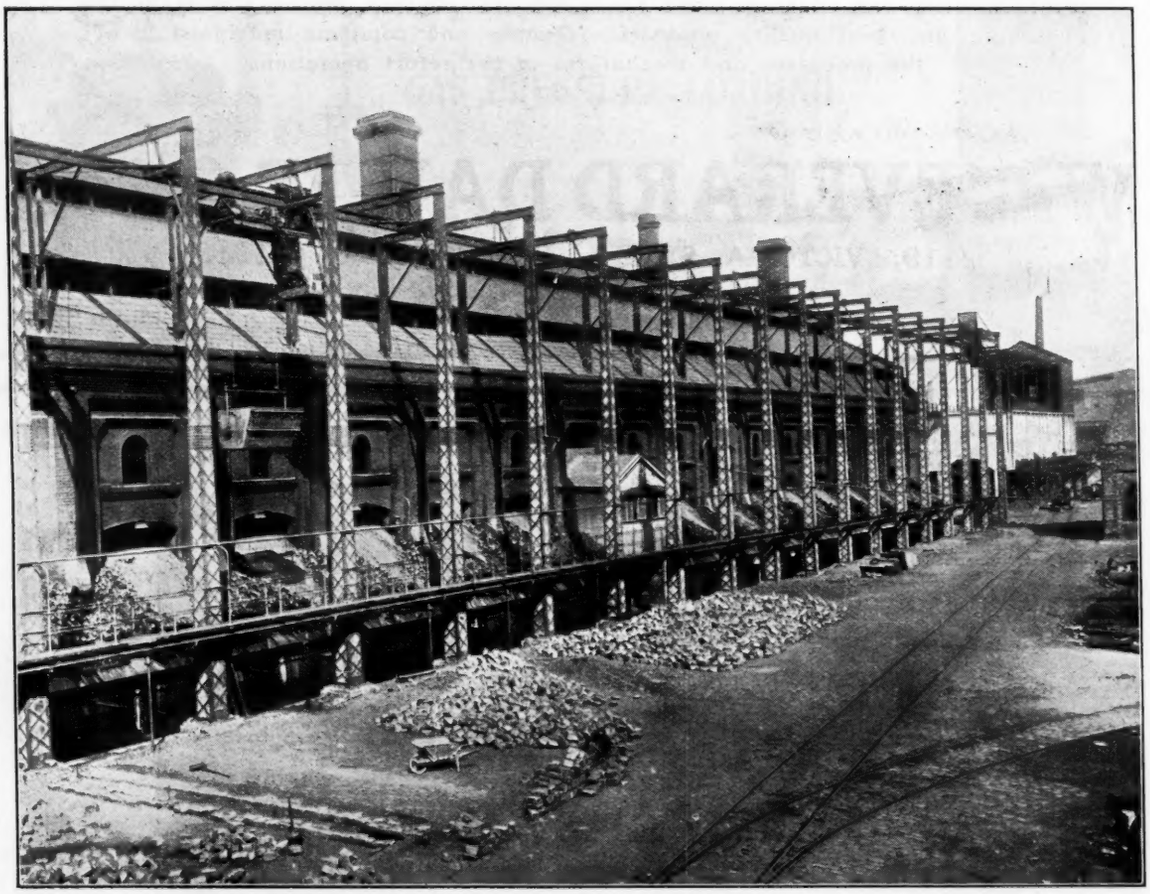
Telegrams: DRAKETED, HALIFAX. *Telephone:* 543 (3 lines).



Telpher Plant and Coke Bench used in conjunction with Patent Hot Coke Transporter.

HORIZONTAL AND VERTICAL CARBONISING PLANTS.

COAL AND COKE HANDLING PLANTS.
STOKING MACHINES.
HOT COKE TRANSPORTERS.

CONDENSERS.
WASHERS.
SCRUBBERS.
PURIFIERS.

CAST IRON AND STEEL TANKS.
ELECTRICAL GENERATING PLANTS, &c.

INSTAL OUR

HOT DRAINER

(Patent No. 178,046)

IN PLACE OF YOUR DRAINING TABLE
AND OBTAIN HIGH GRADE

SULPHATE OF AMMONIA

FILL YOUR CONDENSERS WITH
LESSING PATENT

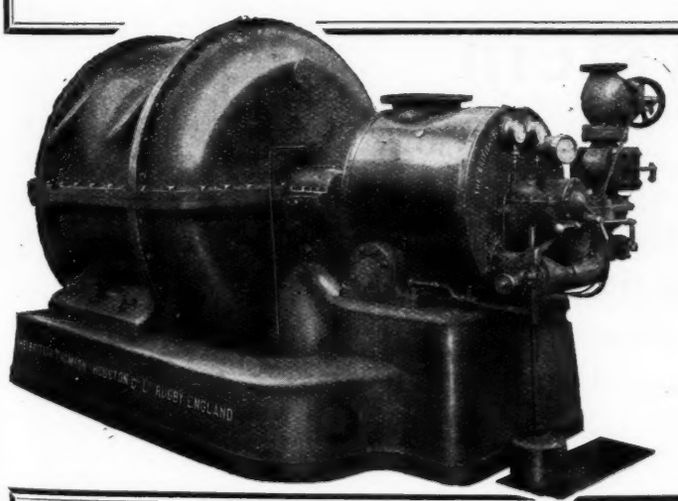
CONTACT RINGS

AND AVOID

NAPHTHALENE TROUBLES

THE HYDRONYL SYNDICATE, LTD.,
27, CLEMENT'S LANE, LONDON, E.C. 4

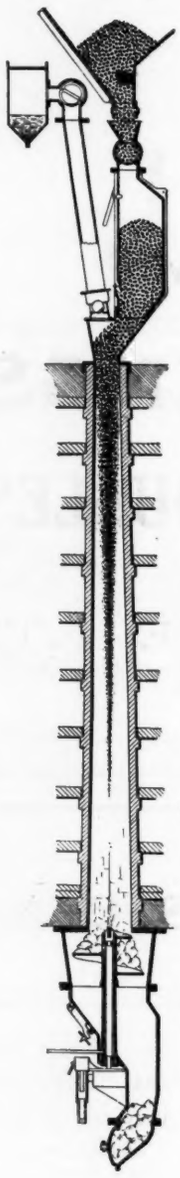
Turbo Gas Exhausters.



B.T.H. Turbo Gas Exhausters possess the combined advantages of low steam consumption, negligible maintenance costs, the ability to maintain a perfectly steady vacuum irrespective of output, and no internal lubrication necessary. They are of simple construction and of small size in comparison to output.

The British Thomson-Houston Coy., Ltd.,

Electrical Engineers *and Manufacturers,*
Head Office & Works, RUGBY, ENGLAND.



MAKE THE

MOST

OF THE

GAS REGULATION ACT,

1920,

BY ADOPTING

THE

Glover-West

System

WEST'S GAS IMPROVEMENT CO. Limited

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MANCHESTER, Central 5961 (3 lines)

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NEW YORK (U.S.A.) : 150, Nassau Street
Cable Address :— "VERTICALS, NEW YORK"
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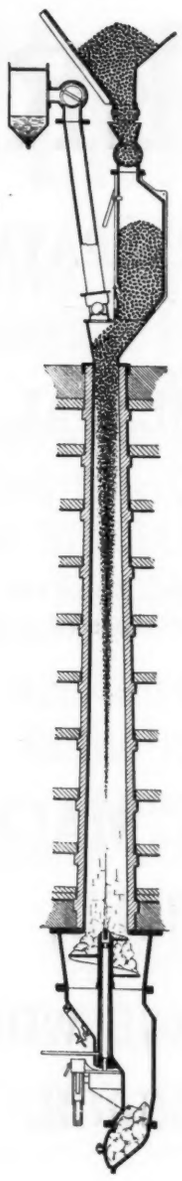
Glover-West System



In the Tests of the Fuel Research Board on the Carbonization of Mitchell Main Gas Nuts the following results were obtained:

TEST NUMBER	D	E	F	G	Increases
COAL—tons per retort per day	2·52	2·48	2·56	2·48	Constant
STEAM per cent. on coal carbonized ...	Nil.	5·06	12·44	20·53	—
GAS—cu. ft. per ton ...	13,100	16,430	20,060	22,580	72%
cu. ft. per retort ...	33,012	40,746	51,353	56,000	70%
THERMS PER TON	71·3	84·9	95·7	104	46%
Therms per retort per day	180	211	245	257	43%
Calorific value B.Th.U. gross ...	544	517	477	460	—
Inerts in gas, per cent.	11·4	11·0	10·8	10·6	Nil
COKE—total make in cwt. per ton of coal ...	14·5	13·9	13·3	13·2	Less by 1·3 cwt.

This means

70 % of water-gas can be added to the results of dry distillation with

NO EXTRA CAPITAL COST

for water-gas plant

NO EXTRA LABOUR COST

NO DECREASE IN COAL CARBONIZED

9,480 cu. ft. of additional gas is made from 1·3 cwts. of coke

NO INERTS ARE ADDED TO THE GAS

For Particulars and Estimates apply

WEST'S GAS IMPROVEMENT CO. Limited

ENGINEERS

Miles Platting, MANCHESTER

Telegrams:— "STOKER, MANCHESTER"

Telephone:— MANCHESTER, Central 5961 (3 lines)

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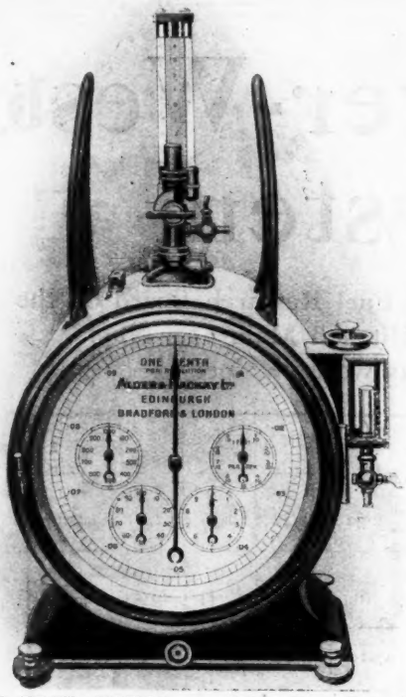
Telegrams:— "IMVERTRET, WESTCENT, LONDON"

Telephone:— LONDON, REGENT 387

NEW YORK (U.S.A.): 150, Nassau Street

Cable Address:— "VERTICALS, NEW YORK"

Telephone:— BEEKMAN 1420



WET TEST METER, 0·1 Cubic Foot Capacity.

GAS METERS.

ORDINARY, PREPAYMENT and EXPERIMENTAL.

"Quality First." The name "Alder & Mackay" has been the symbol of best quality for nearly three-quarters of a century.

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WILTON'S PLANTS

FOR

SULPHATE OF AMMONIA
NEUTRAL SULPHATE
BENZOL

Entirely new process for continuous

TAR DEHYDRATION, OIL DISTILLATION AND CRACKING—

Reducing the residues by 20%

SULPHURIC ACID
CARBOLIC ACID

PATENT
LIMING APPARATUS

Special design
SATURATORS

LEAD REPAIR WORK

FORCED DRAUGHT FURNACES
(1920 type) for burning Coke Breeze in Gas Works

Over 120 complete WILTON Sulphate Plants installed in the British Isles and 10,000 Furnaces.

Address Enquiries:—

THE CHEMICAL ENGINEERING & WILTON'S PATENT FURNACE Co., LTD.
76, Victoria St., London, S.W.,
and
SOCIETE WILTON. Boulevard Antoine Gautier, Bordeaux.
Telephone - - - - VICTORIA 2417.

Bourne's Naphthalene Solvent.

"GAZINE"

(Registered in England and Abroad)

A Radical Solvent and Preventative of Naphthalene Deposits, and for the Automatic Cleaning of Mains and Services. It is used also for Enriching and Odorizing Water Gas.

Used successfully for 18 years by many Gas Companies.

SUPPLIED ONLY BY

C. BOURNE
West Moor Chemical Works,
KILLINGWORTH

OR THROUGH HIS AGENTS

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Pilgrim House, Newcastle-on-Tyne.

Telegrams: "DORIC, NEWCASTLE-ON-TYNE." "BOURNE, FOREST HALL."
National Telephone 2947.

Stock P·A·L Globes

THE BEST FOR ALL BURNERS

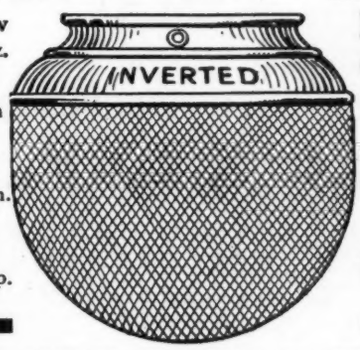
Prevents Fires.

Order **now** sample 2 doz.

Increased Illumination Positive.

No Stock Depreciation.

They sell without Salesmanship.



SAVES: Money, Gas, Mantles, and Globes. Always Reliable.

ASK YOUR REGULAR MERCHANT TO SUPPLY YOU,
OR ORDER DIRECT FROM

SAFETY GLOBE CO.,

18/- per dozen Trade, net.
Don't pay more.
(Carriage on 2 doz. lot, 1/3 extra.)

"Pifco House,"
MANCHESTER.

PROTECT A LITE

NEVER BREAK

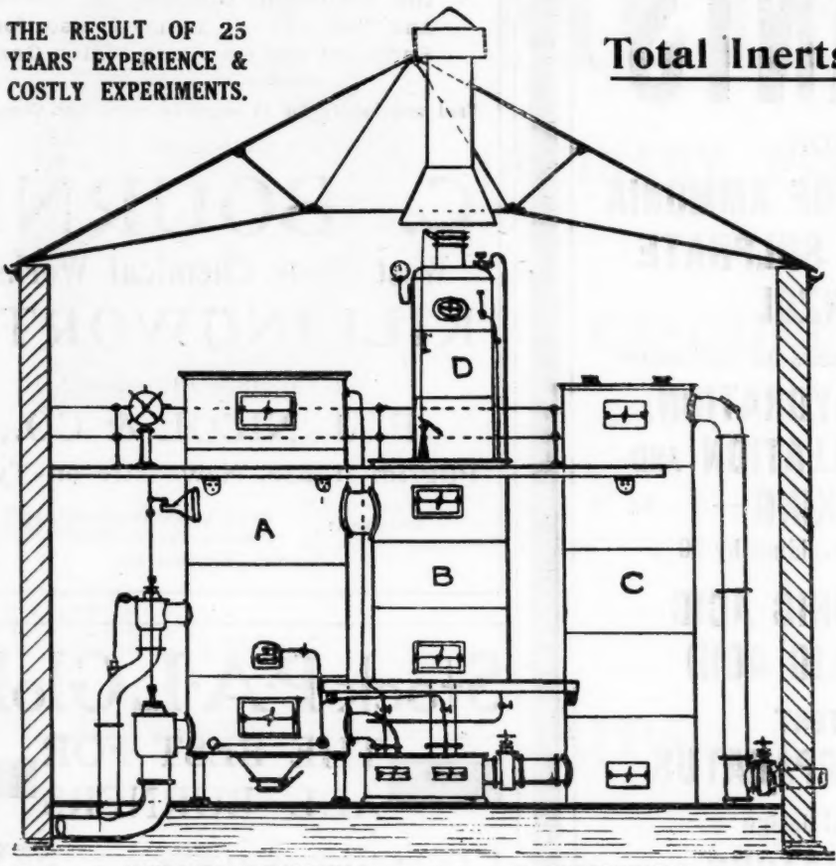
IMPORTANT DEVELOPMENTS.

Tully Gas Plant 1922 TYPE

CARBURETTED TULLY GAS, 500 B.Th.U.

THE RESULT OF 25 YEARS' EXPERIENCE & COSTLY EXPERIMENTS.

Total Inerts under 7%



A—IMPROVED GENERATOR. B—SUPERHEATER.
D—STEAM BOILER. C—SCRUBBER CONDENSER.

In UNITS of 50,000 c.ft. to 1 Million per day operated by one man.

Complete with Self-Steaming Boiler and Superheater for Oil Carburation when required.

Analysis of Tully Gas, from all Coal, December, 1921.

CO_2	2·2
O_2	0·2
CO	39·2
C_nH_{2n}	1·5
CH_4	12·2
H_2	41·0
N_2	3·7
	100·0

TULLY'S GASIFICATION PLANT of **1922** fills ALL REQUIREMENTS of the GAS REGULATION ACT.

50,000 to 60,000 c.ft. of 350 to 400 B.Th.U. Tully Gas.

EXTRA B.Th.U.'s BY USE OF OIL.
MOST ECONOMICAL PLANT for Production of TULLY GAS, or CARBURETTED TULLY GAS for all Purposes.

TULLY GAS PLANTS, Ltd.

SOLE MANUFACTURERS OF TULLY'S PATENT GASIFICATION PLANT.

MILLGATE, NEWARK-ON-TRENT.

TELEGRAMS: DAMPER, NEWARK. TELEPHONE No. 174.

LONDON OFFICE: 47, VICTORIA STREET (Ground Floor), S.W. 1.
Telegrams: DAMPER, VIC, LONDON. Telephone: VICTORIA 8476.

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TULLY PLANTS ORDERED SINCE MARCH, 1919.

			Cub. ft. per 24 hours.
Runcorn	1	Set	300,000
Holyhead	1	,,	100,000
Newark	1	,,	300,000
Henley	1	,,	150,000
East Grinstead	1	,,	200,000
Sandown	1	,,	100,000
Grantham	1	,,	300,000
Heywood	1	,,	300,000
Normanton	2	,,	100,000
Enniskillen	1	,,	50,000
Llandudno	1	,,	300,000
Swadlincote	1	,,	200,000
Irthlingborough	1	,,	100,000
Knottingley	1	,,	100,000
Newcastle, Staffs	1	,,	300,000
Conway	1	,,	100,000
Burnham	1	,,	75,000
Burntisland	1	,,	200,000
Bridgend	1	,,	100,000
Limerick	1	,,	300,000
Colwyn Bay	1	,,	300,000
Carmarthen	1	,,	100,000
Kirkby in Ashfield	1	,,	100,000
Kelso	1	,,	100,000
Otley	1	,,	100,000
Blandford	1	,,	100,000
Grange & Cartmel	1	,,	100,000
Tiverton	1	,,	100,000
Formby	1	,,	100,000
Kidderminster	2	,,	300,000
Tonbridge	1	,,	500,000
Larne	1	,,	100,000
Kelty	1	,,	150,000
Horley	1	,,	150,000
East Dereham	1	,,	100,000
Aberystwith	1	,,	200,000
Harpenden	1	,,	300,000
Kildwick	1	,,	200,000
Haslemere	1	,,	150,000
Southbank	1	,,	300,000
Mirfield	1	,,	300,000
Whitby	1	,,	300,000
Featherstone	2	,,	100,000
Guernsey (repeat order)	1	,,	500,000
Thirsk	1	,,	100,000
Newark (repeat order)	1	,,	300,000
Llandudno (repeat order)	1	,,	300,000
Hexham	2	,,	150,000
Selby	2	,,	150,000
Wellington (Salop)	1	,,	200,000
Porthcawl	1	,,	200,000
Teignmouth	1	,,	200,000
Letchworth	2	,,	300,000
Colwyn Bay (repeat order)	1	,,	300,000
Whitstable	1	,,	100,000
Cordoba	1	,,	200,000
Yeovil	1	,,	200,000
Jersey (repeat order)	1	,,	300,000
Dursley	2	,,	150,000
Cirencester	1	,,	100,000
Goring-on-Thames	1	,,	75,000
Grays & Tilbury	2	,,	300,000
Castleford	1	,,	300,000
Haverton Hill-on-Tees	2	,,	100,000
Batley	2	,,	300,000
Haslingden	1	,,	200,000
Ossett	1	,,	300,000
Seaton	2	,,	75,000

			Cub. ft. per 24 hours.
Tayport	1	Set	75,000
Ryde, Isle of Wight	2	,,	150,000
Knottingley (repeat order)	1	,,	100,000
Newquay	2	,,	75,000
Pontefract	2	,,	200,000
Congleton	1	,,	200,000
Fleetwood	1	,,	300,000
Prestonpans	2	,,	100,000
Plymouth	2	,,	500,000
Cork	1	,,	300,000
Selkirk	1	,,	150,000
Morley	1	,,	200,000
Sheffield	2	,,	500,000
Bathgate	1	,,	150,000
Littleborough	1	,,	200,000
Newport, Isle of Wight	1	,,	150,000
Scunthorpe	2	,,	300,000
Langley Mill	1	,,	300,000
Bolton	1	,,	500,000
Walton-on-Thames	2	,,	150,000
Kettering	1	,,	300,000
Bishop Auckland	2	,,	150,000
Draycott	1	,,	200,000
Bedford	2	,,	750,000
Colne	1	,,	500,000
Musselburgh	1	,,	300,000
Ambleside	1	,,	100,000
Leyland	2	,,	200,000
Wisbech	1	,,	150,000
Altrincham	2	,,	200,000
Grange-over-Sands (repeat order)	1	,,	100,000
Derby	1	,,	500,000
Gravesend	1	,,	300,000
Keith	1	,,	50,000
Carnarvon	1	,,	300,000
Eiland	2	,,	300,000
Hemsworth	1	,,	100,000
South Elmsall	1	,,	100,000
Hindley	2	,,	300,000
Abercarn	1	,,	150,000
Grangemouth	1	,,	200,000
Duns	1	,,	50,000
Conway (repeat order)	1	,,	200,000
Bungay	1	,,	50,000
Halifax	4	,,	500,000
Reus	1	,,	100,000
Bathgate (repeat order)	1	,,	150,000
Anstruther	1	,,	75,000
Inverurie	1	,,	75,000
Maldon	1	,,	100,000
Stonehaven	1	,,	100,000
Moffat	1	,,	50,000
Cirencester (repeat order)	1	,,	100,000
Redcar	2	,,	300,000
Egremont (Cumberland)	1	,,	150,000
Alderney (Channel Islands)	2	,,	50,000
Wick and Pulteneytown	1	,,	75,000
St. Mary Church, Torquay	2	,,	200,000
Abercarn (repeat order)	1	,,	150,000
Kobe (Japan)	2	,,	500,000
Bangor	1	,,	200,000
Louhans (France)	1	,,	150,000
St. Germain (France)	1	,,	500,000
Wellington (Salop) (repeat order)	1	,,	300,000
Sleaford	1	,,	150,000
Goring-on-Thames (repeat order)	1	,,	150,000
Kobe (Japan) (repeat order)	1	,,	500,000

PLANTS OF THE FOLLOWING SIZES IN STOCK: 50,000, 75,000, 100,000, 150,000, 200,000, 250.000, 300,000, AND 500,000 CUBIC FEET PER 24 HOURS.

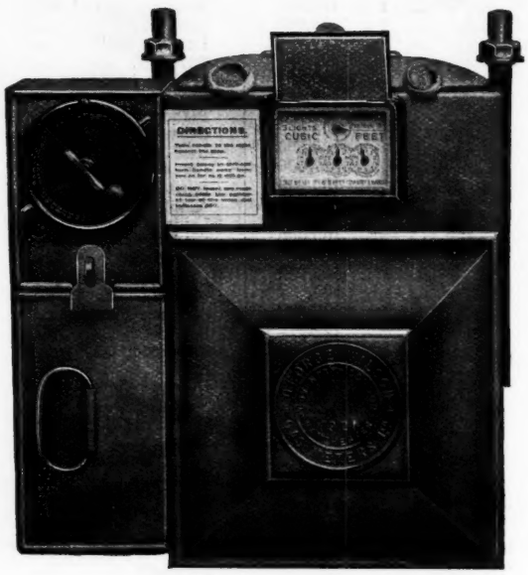
GEORGE WILSON GAS METERS

LIMITED

Ordinary, Prepayment and Stop Meters.

Meters of slot or stop principle specially constructed for use in Hotels and Boarding Houses with gas fires, pressure wave lamp controllers, etc.

The "PILOT" Slot Meter



SALIENT POINTS WORTH NOTICING.

Effective radius from 3 c.ft. to 45 c.ft.

Valve opens when first coin operates.

Inside or outside seals, as required.

Strong and efficient. Large money box.

Insertion point at the front, all slot mechanism and valve outside the meter.

COVENTRY . . . . Foleshill Road Telegrams: Gasmeter. Telephones 596

London . 46/47, Auckland St., S.E.11 „ Gaseous Lamb. „ Hop 647

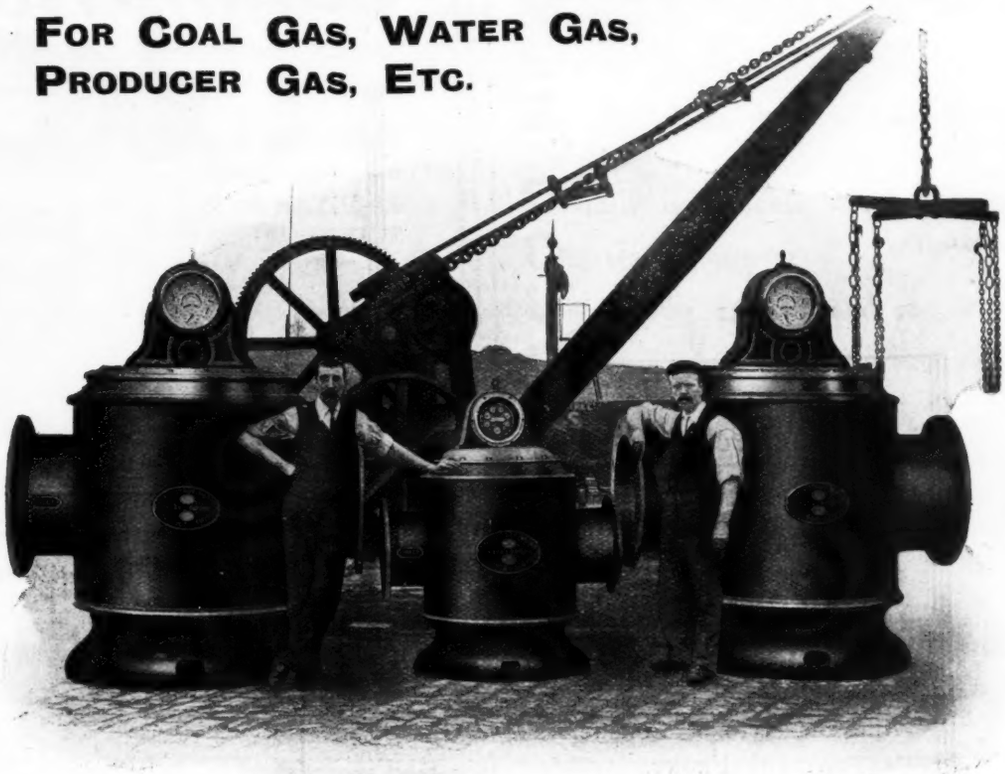
Manchester . . 268, Stockport Road „ Gasmeter. „ Rusholme 976

Edinburgh . . Mr. Daniel Macfie, 1, North Saint Andrew St.

ROTARY METERS

FOR COAL GAS, WATER GAS, PRODUCER GAS, ETC.

ACCURATE



RELIABLE

The Tests given below are Incontrovertible Evidence of the Accuracy and Efficiency of Rotary Meters.

TEST MADE BY THE LATE ISAAC CARR, ESQ., OF A ROTARY METER.

Capacity 18,000 to 180,000 cub. ft. per hour.

RATE PER HOUR.	PRESSURE ABSORBED WITH AIR.	RESULT.
20,000 cub. ft.	Nil	04·% Fast
45,000 ,,	Nil	Correct
70,000 ,,	1/10"	do.
90,000 ,,	2/10"	do.
110,000 ,,	4/10"	do.
180,000 ,,	8/10"	do.

EVERY ROTARY METER IS THOROUGHLY TESTED & CAREFULLY CALIBRATED BEFORE DISPATCH.

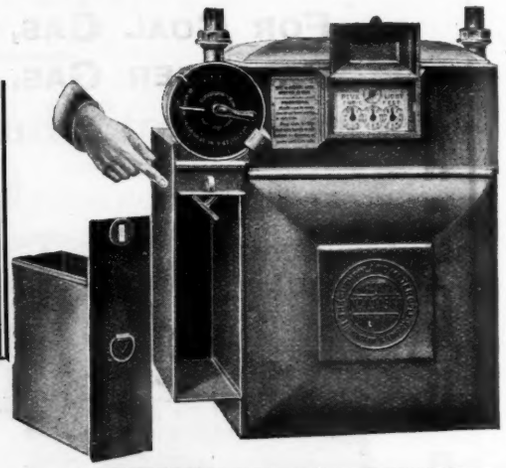
UNSOLICITED TEST OF ROTARY METER RUN TANDEM WITH ORDINARY WET DRUM TYPE OF STATION METER.

WET DRUM TYPE.	ROTARY TYPE.
71,000	71,000
82,000	81,000
91,000	91,000
90,000	89,000
80 000	80,000
83,000	84,000
87,000	86,000
73,000	73,000
83,000	83,000
80,000	80,000
82,000	82,000
83,000	83,000
90,000	90,000
80,000	80,000
85 000	85,000
75,000	76,000
65,000	66 000
65,000	65,000
65,000	65,000
70,000	70,000
66,000	66,000
64,000	64,000
65,000	65,000
61,000	61,000
1,836,000	1,836,000

THE ROTARY METER CO. LTD.

VICTORIA WORKS, WHITEFIELD, MANCHESTER.

The Sutherland Meter Co., Ltd., Witton, Birmingham.



Perfection in Simplicity.

A few of the ADVANTAGES in use of THE

SUTHERLAND-KING Patent Attachment Prepayment Meter:—

ALL OPERATIONS—Consumers' *and* Gas Co.'s —AT THE FRONT.

To change the setting *in situ*, simply one turn of the thumbscrew—*no other* alteration or adjustment. Takes *less* than a minute.

No seals, no change wheels, no complicated mechanism.

The Setting cannot be altered without removing the Cash Box.

Unless the Meter is set correctly, the Cash Box cannot close.

Improved Valve Action—opens fully, quickly.

Fewest Working Parts.

There are Thousands of our SUTHERLAND-KING in use.

REPAIRS = = = to ANY MAKE of Meter have been for many years a SPECIALITY with us.

ORDINARY AND PREPAYMENT METERS.

The old "LIGHT" sizes and the NEW STANDARD sizes IN STOCK.

THE SUTHERLAND METER CO., LTD.

Telegrams: "Meteristic," Birmingham. **WITTON, BIRMINGHAM.** Telephone: East 236.

GAS PURIFYING MATERIALS

SPECIALITY:—

NATURAL ENGLISH BOG ORE mined from the Company's own deposits and enriched with NATURAL ENGLISH HYDRATED OXIDE OF IRON.

NO SAWDUST OR OTHER INERT MATERIAL USED OR REQUIRED FOR LIGHTENING.

Dutch or Belgian Bog Ore Supplied, and also Artificial Oxides.

SPENT OXIDE PURCHASED.

THE BRITISH GAS PURIFYING MATERIALS CO., LIMITED,

13, ARCADIAN GARDENS, WOOD GREEN, LONDON, N. 22.

Telegrams: "BRIPURIMAT WOOD, LONDON." Telephone: PALMERS GREEN 608.

Just as soon as you have
A consignment of Meters for Repairs,
Mention the matter to us, and our
Express Repair Service will
Speedily make them as good as new.

Dougall is a name which has made
Our Gas Industry, [history in
Universally known, and stands as a
Guarantee for
All that is sound and
Lasting—we ask
Leave to place our experience at your [disposal.

CHISWICK METER & ENGINEERING WORKS,

70, Strand-on-the-Green, Chiswick, London, W. 4.

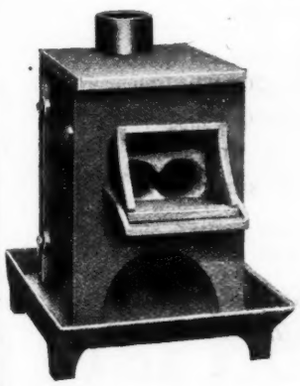
Te'ephone: Chiswick 1965.

Promote INDUSTRIAL ECONOMY and INCREASE GAS SALES

BY SELLING

TILLEY SOLDERING STOVES & INTERNALLY-HEATED BOLTS

LOWEST POSSIBLE CONSUMPTION at either High or Low Pressure.
HEAT CONSERVED BY REGENERATING FLUES.



For **High Pressure Gas.**

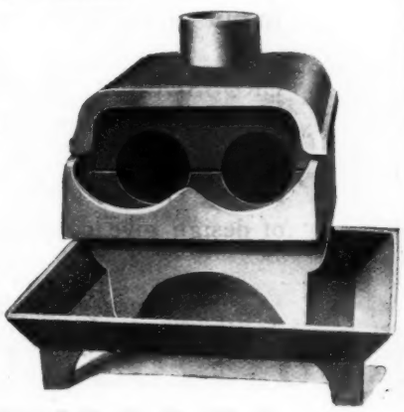
No 1 Size, for two 2 lb. bolts, **35/-** each.

No. 2 Size, for two 4 lb. bolts, **52/6** each.

For **Low Pressure Gas.**

For two 2 lb. bolts, **35/-** each.

Fire Brick Linings.
No Smell.



Have some in your Showroom.

Internally-heated Soldering Bolt (H. or L. pressure), 22/6 each.

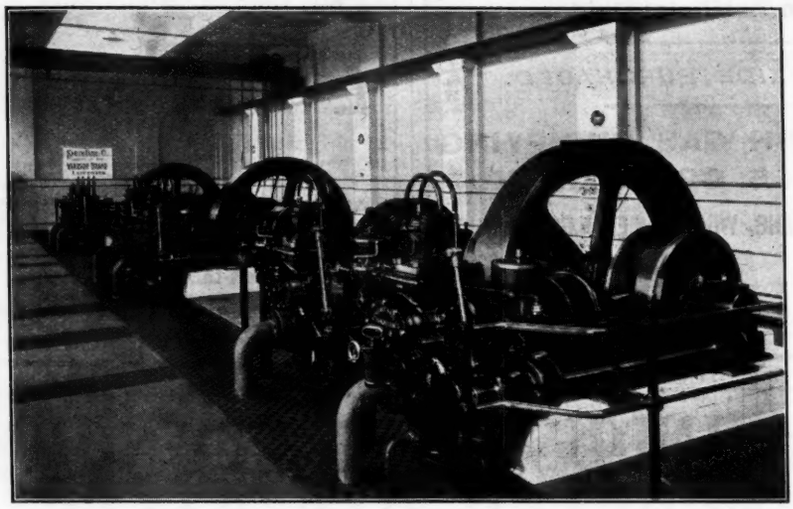
THE *LISTS AND ALL PARTICULARS FROM*

TILLEY HIGH-PRESSURE GAS SYN. LD., Brent Works, Hendon, N.W. 4

DEPENDABLE POWER FOR GAS-WORKS

CROSSLEY
GAS ENGINES

POWERS 18 TO 234 B.H.P.



Typical Installation of Crossley Gas Engines direct coupled to Electric Generators.

For driving the various machinery required in a Gas-Works, electricity generated on the premises by gas-driven sets has many advantages, and provides for economical working.

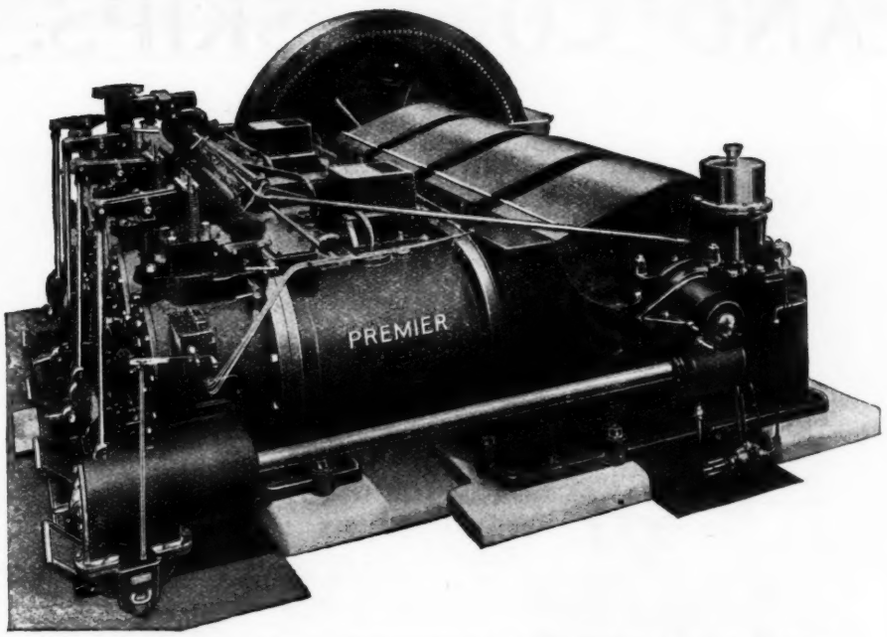
CROSSLEY GAS ENGINES on account of their close governing, even turning moment, and low cyclic variation are recognised by gas engineers throughout the world as being the ideal power unit for driving electric generators. Their strong construction and simplicity of design give continuous service and long life.

Crossley Gas Engines maintain all the features on which their reputation for quality and service has been built.

CROSSLEY BROTHERS LTD.
OPENSHAW MANCHESTER

London Office: 139-141, Queen Victoria Street, E C. 4.

PREMIER
LARGE GAS ENGINES



Premier Standard 4-cylinder, four-crank engine of which two sets of 400 B.H.P. each are being supplied to the Sheffield Gas Co. for Electric Power purposes.

There are many advantages in using electrical power for driving the coal handling plant and other machinery in a large gas-works, and the current is most economically produced by gas engines.

For this purpose Premier Engines are eminently suitable on account of their Even Turning Moment, Low Cyclic Variation, and Great Reliability. They are particularly designed for driving direct-coupled Alternators in parallel.

HORIZONTAL MULTI-CYLINDER ENGINES, 250 TO 1000 B.H.P.
VERTICAL MULTI-CYLINDER ENGINES, 1000 B.H.P. UPWARDS.

THE PREMIER GAS ENGINE CO., LTD.
(CROSSLEY BROTHERS, LTD.)

SANDIACRE **Nr. NOTTINGHAM**

London Office: 139-141, Queen Victoria Street, London, E.C. 4.

CRANES

TO WORK COAL GRABS AND COKE SKIPS.

FIG. 1339.

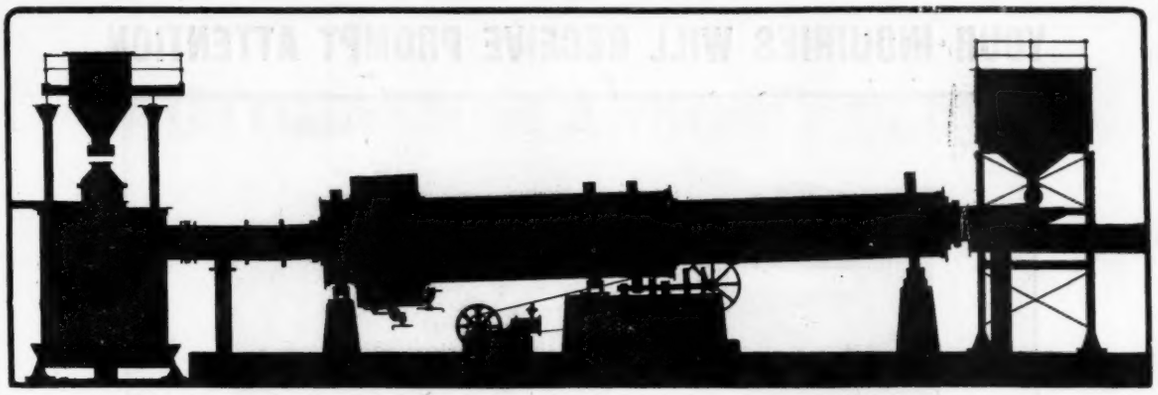
2½ TONS AT 45 FT. RADIUS.

"TOPLIS" HORIZONTAL LUFFING MOTION.

STOTHERT & PITT, LTD.,

BATH, ENGLAND.

LONDON OFFICE: 38, VICTORIA ST., S.W.



1 TON OF COAL
WHEN DISTILLED IN
ROTARY RETORTS
BY OUR PROCESS
PRODUCES

	I. Smokeless Domestic Fuel.	II. Complete Gasification for Town Gas.	III. Complete Gasification for Power and Furnace Gas.
Semicoke or Smokeless Fuel ...	0·5 tons	None	None
Cubic Feet of Gas	35/40,000	36/38,000	100/110,000
B.Th.U. Value of Gas	220/230	380/400	175/180
Cubic Feet of Blow Gas	None	50/60,000	None
B.Th.U. Value of Blow Gas ...	None	70/90	None
Sulphate of Ammonia	12/18 lbs.	12/22 lbs.	None
Low Temperature Tar Oils ...	15/20 galls.	13/18 galls.	14/18 galls.
Fractions up to 170° C.	1·0/1·5 galls.	Left in gas	Left in gas
170°—230°	2·0/2·5 galls.	2·0/3·0 galls.	2/3 galls.
230°—270°	3·0/3·2 galls.	3·0/3·2 galls.	3·0/3·5 galls.
270°—350°	3·5/4·0 galls.	3·5/4·0 galls.	3·2/4 2 galls.
350°—400°	3·5/4·0 galls.	3·0/4·0 galls.	3·0/4·0 galls.
Hard Pitch	3·0/4·0 galls.	3·0/4·0 galls.	3·0/4·0 galls.
Motor Spirit from Gas...	1·0/2·0 galls.	Left in gas.	Left in gas

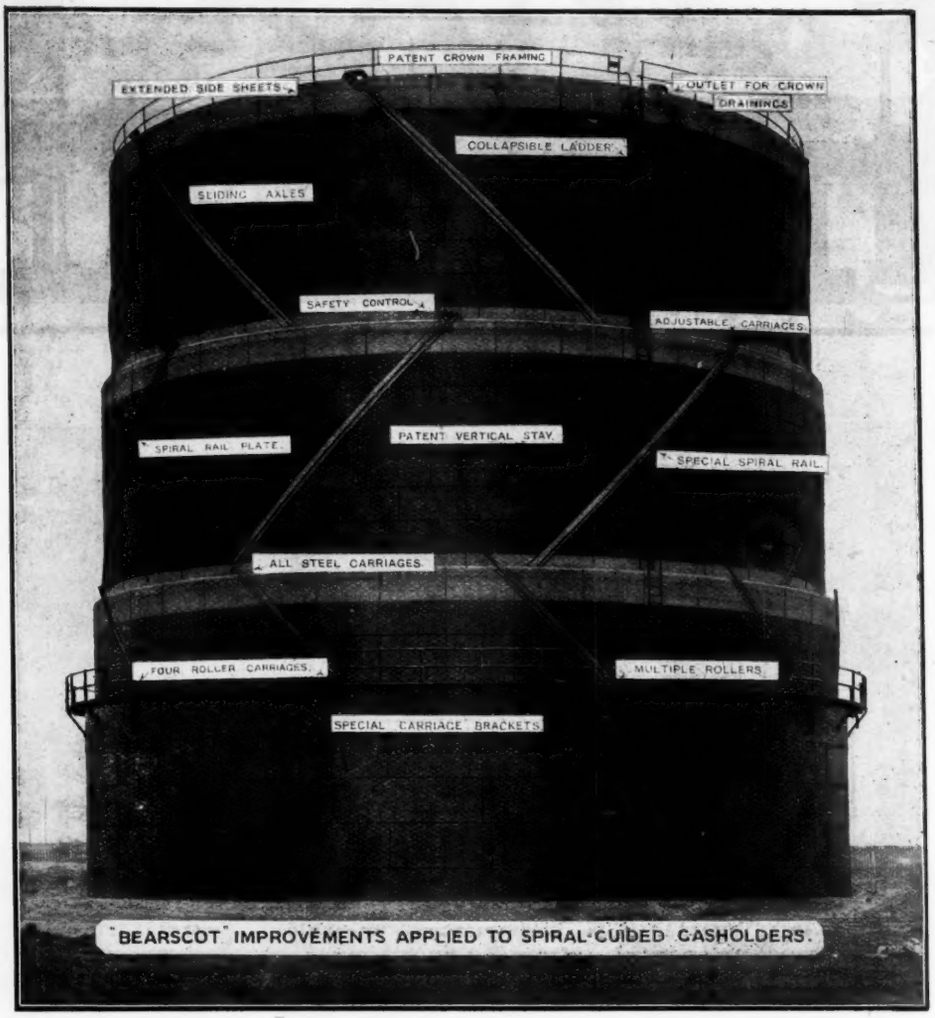
FOR FULL PARTICULARS APPLY TO

SENSIBLE HEAT DISTILLATION,
100, VICTORIA STREET,
LONDON, S.W.

Telegrams: "Bulkdist, Sowest," London.
Telephone: Victoria 2512.

LARGE UNITS. LOW CAPITAL OUTLAY.
MINIMUM WORKING COSTS. MAXIMUM EFFICIENCY.

YOUR INQUIRIES WILL RECEIVE PROMPT ATTENTION



R. & J. DEMPSTER Ltd. purchased the **original patents,** and were for many years the sole makers of the **SPIRAL GUIDED GASHOLDER.** We have erected upwards of 600 of the spirally guided type, and these are operating in **ALL PARTS OF THE WORLD.**

WE HAVE RECEIVED ORDERS FOR SPIRAL GASHOLDERS WITH THE "BEARSCOT" SPECIALITIES RANGING IN CAPACITIES FROM

— TWENTY-FIVE THOUSAND TO —
— SEVEN MILLION CUBIC FEET —

R. & J. DEMPSTER LTD.
MANCHESTER

London Office:
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WESTMINSTER, S.W 1

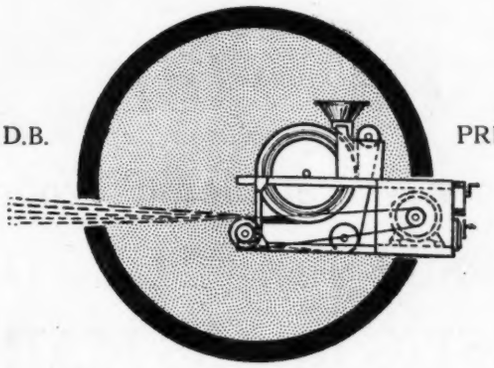
Telephones:
CENTRAL 54 & 2296
London Office:
VICTORIA 7426

Perfect

AUTOMATIC CARBONIZATION

Has not yet been achieved, but—it is almost realized by the use of Jenkins' D.B. Patent Stoking and Conveying Machinery.

Beautifully engraved plates of our standard machines forwarded to all enquirers mentioning List K 39.

THE D.B.  PRINCIPLE

W. J. JENKINS & COMPANY, LIMITED, RETFORD, NOTTS.

Telegrams: Jenkins, Retford. Telephone: 131 & 132 Retford

"Cannon" Cookers.

HIGHEST EFFICIENCY! SILENT BURNERS!

The "OPHIR"

is a splendid model, embodying the latest improvements.

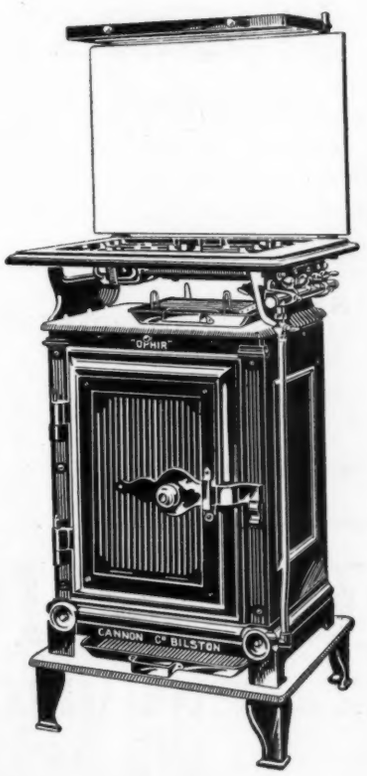
Double-cased, and lined with enamelled steel plates. Fitted with high-efficiency hotplate, a great feature being the SILENCE OF THE BURNERS. The cast-iron stand, with enamelled top, raises the Cooker for convenient access to the oven, and renders easy cleaning of floor.

The "Ophir" is a grand Cooker for SLOT and HIRING purposes.

⊙⊙⊙⊙

Particulars gladly furnished by

CANNON IRON FOUNDRIES, LTD.,
DEEPFIELDS, - Nr. BILSTON, STAFFS.



NAPHTHALENE SOLVENT.....

This new Petroleum Product

DISSOLVES THE DEPOSITS IN GAS MAINS

WITHOUT

AFFECTING IN ANY WAY THE QUALITY OF THE GAS ITSELF

Sold only by

British Petroleum Co., Ltd.

22, FENCHURCH ST, LONDON E.C.3

TWO NEW BLAND PATENT BURNERS

IT DOES NOT MATTER whether you are making 350 or 550 B.Th.U. GAS, these two new Burners will suit your conditions and give splendid DUTY.

No. 1922.

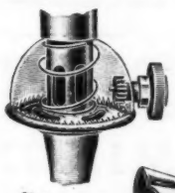
New Universal type made of polished **Aluminium** with Super-heater and fitted with New **Ratchet** primary Air Regulator and Dust Cap. Suitable for use with Vitreosil Ware.

Section of No. 84.

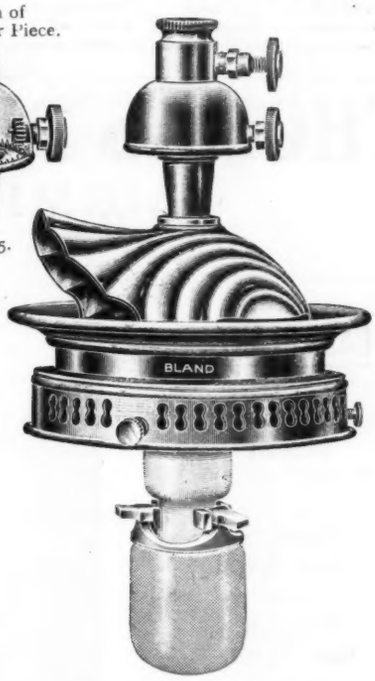
No 84
(Pat. 161834).

Suitable for any condition of make and pressure.

Section of Ratchet Air Piece.



Pat. 10035.



A No. 8.

Universal type with metal or porcelain shell, fitted with new **Ratchet** primary Air Regulator and Dust Cap, Venturi Bunsen tube, also new patent **Silent** two-piece (No. 84) combined Bunsen tube and nozzle with Venturi inner tube and gauze.

THE BLAND LIGHT SYNDICATE, LIMITED,

Registered Offices & Show Rooms: 29, LITTLE TRINITY LANE, LONDON, E C. 4.

WILFRED ROBBINS Ltd.,

Golds Hill Ironworks, GREAT BRIDGE, STAFFS.

LOWEST PRICES. PROMPT DELIVERY. FIRST CLASS WORKMANSHIP.

STEEL ROOFS, BUILDINGS, & CONSTRUCTIONAL STEELWORK

Telephone: WEST BROMWICH 461. **OF ALL KINDS.** Telegrams: ROBBINS, GREAT BRIDGE.

Workmanship and Materials of the Highest Quality.

PECKETT'S LOCOMOTIVES.

Built to any Specification or Gauge.

PECKETT & SONS, LTD.,
ATLAS LOCOMOTIVE WORKS, BRISTOL.

HARDMAN & HOLDEN, LTD., MANCHESTER.

Telegraphic Addresses:
"BENZOLE, MANCHESTER."
"OXIDE, MANCHESTER."

Telephones:
Manchester—Miles Platting and Clayton } City 8666 (8 lines). Oxide, 5883 Central Manchester.

All Bye-Products from the Distillation of Coal dealt with.

SPECIALITIES { Hydrated Oxide of Iron for Gas Purification, and of different Strengths to suit conditions of Purification, Sulphuric Acid (free from Arsenic) for Sulphate of Ammonia Manufacture, Recovered Sulphur, and Prussiates of Soda, Spent Oxide bought on Sulphur and Cyanide Contents, Tar and Gas Liquor purchased. *See our Advertisement last week.*

THOMAS PIGGOTT AND CO., LIMITED.

BIRMINGHAM.

GAS PLANT.

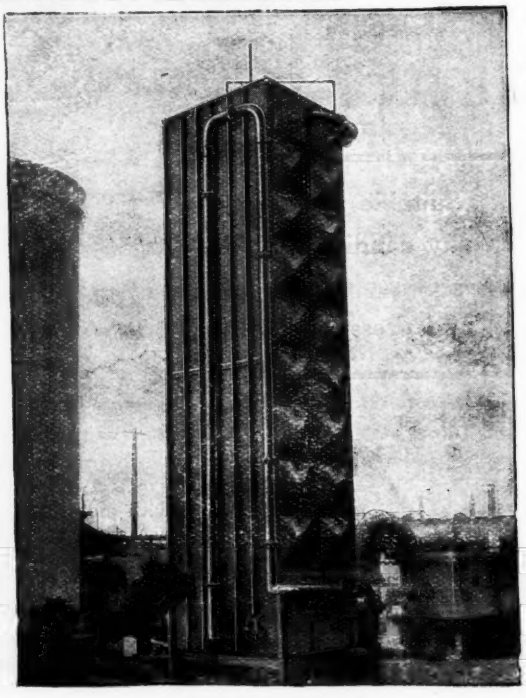
Gasholders with or without Guide Framing

Barker's Patent Spiral.

Complete Gas Plants.

Steel Pipes welded or rivetted.

Tanks, pressed steel, also rivetted or welded.



"Atlas" Condenser.

BYE-PRODUCT PLANT

Motor Spirit Plant.

Sulphate of Ammonia Plant

Benzol Plant.

Naphthalene Plants, pressed and pure.

Stills for Tar, Ammonia, Benzol, & Phenol.

Condensers & Dephlegmators

ALL MADE IN OUR OWN WORKSHOPS.

BRAY BURNERS

FOR

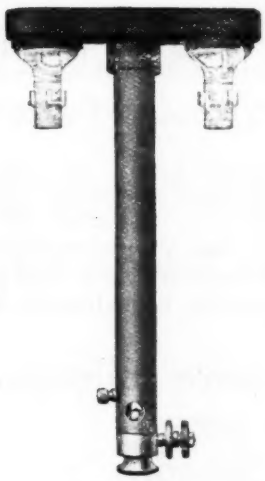
STREET LIGHTING.

HEAVY PRE-HEATING TYPE.

Locking Screws fitted to AIR REGULATOR and GAS ADJUSTER.

CAST IRON OR BRASS.

No. 711/2. Single-Light.



No. 712/2. Two-Light.

No. 717/2. Twin-Light.

No. 713/2. Three-Light.

No. 714/2. Four-Light.

:: :: THE PRICES OF ALL :: ::
BRAY INCANDESCENT BURNERS
HAVE BEEN GREATLY REDUCED.

Full particulars will be sent upon application to

GEO. BRAY & CO., LTD., LEEDS.

The only Motor Spirit with a Guaranteed percentage of benzole

"National" Benzole Mixture is the only motor spirit with a guaranteed percentage of Benzole.

National Benzole Mixture

"The world's best motor spirit"

Contains 50% "National" Benzole guaranteed to N.B.A. Specification and 50% of a super grade No. 1 Petrol (British refined) so skilfully and scientifically blended that the advantages enumerated below are proportionately contained in every drop that passes through the carburettor. Minimises carburettor adjustments whilst it ensures:

20% more mileage.
Added power.
More Speed.
Elimination of pinking and knocking.
Lower Bills and
Greater General Efficiency.

No. 1 Petrol Price

LONDON: Scrubbs Lane, Willesden.
MANCHESTER: 2, Tonman Street, Deansgate.
BIRMINGHAM: 1-7, Hill Street.

USE ONLY N.B.C. LUBRICATING OILS.
NATIONAL BENZOLE CO., LTD.,
30, Grosvenor Gardens,
London, S.W.1

SOUTHAMPTON: Fawley, Hants.
DARLINGTON: Cleveland Buildings, Grange Road.
SHEFFIELD: 1, George Street.

Actual Makers of:—

LIGHTING GLASSWARE for all purposes.
CHEMICAL and HEAT RESISTING GLASSWARE.
ACETYLENE LAMPS for Railways, Engineers, etc., etc.
STAMPINGS, PRESSINGS, and Machined parts in all kinds of metal.
COINS, MEDALS, TOKENS, etc.
CEMENT for repairing and rebuilding furnaces.

ACKROYD & BEST, LTD.,
MORLEY, near LEEDS.

Telephone No.: 86 Morley.

Telegraphic Address: "Lamps, Morley, Leeds."

OXIDE OF IRON
SPENT OXIDE

GAS PURIFICATION & CHEMICAL CO., LTD.,

Telegrams: "PURIFICATION STOCK, LONDON." **PALMERSTON HOUSE, LONDON, E.C. 2.** Telephone: 9144 LONDON WALL.

WATER GAS

BLUE AND CARBURETTED.

OVER **24** YEARS' EXPERIENCE.

DAVISON & PARTNER, LTD.

11, CARTERET ST., WESTMINSTER, S.W. 1.

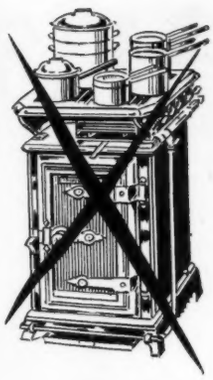
TELEGRAMS: "SAGRETAW, VIC., LONDON." TELEPHONE: VICTORIA 7856.

CLAYTON, SON, & CO., LTD., HUNSLET, LEEDS.

VIEW OF THE LARGE GASHOLDER AT EAST GREENWICH IN ITS WRECKED CONDITION AS A RESULT OF THE SILVERTOWN EXPLOSION, JAN. 19, 1917. THE WORK OF REPAIRING AND RESTORING THE GASHOLDER WAS CARRIED OUT BY CLAYTON, SON, & CO., LTD., FOR THE SOUTH METROPOLITAN GAS COMPANY.

GASHOLDERS AND TANKS

of any Size and Design.



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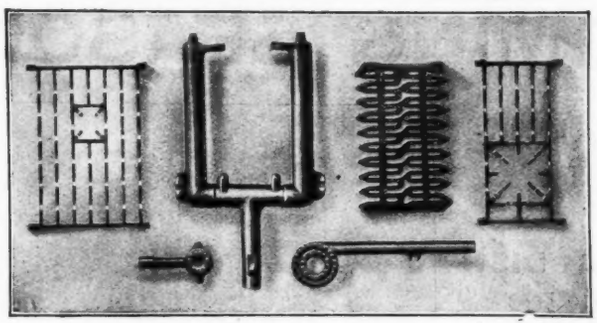

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for all generally used
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Send us samples of the parts you want and the number of each required and there is a good chance that we shall be able to deliver what you want rightaway from stock and at a price below what you are paying now.

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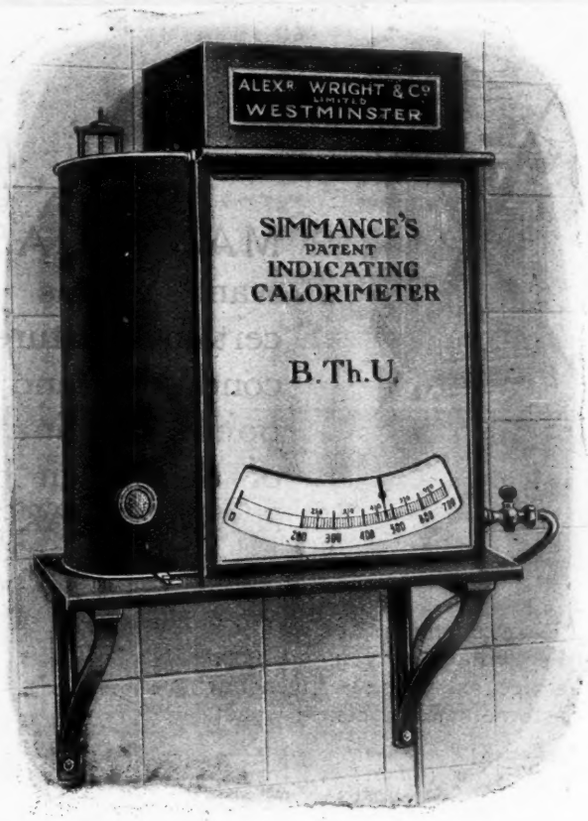

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THE BURNER FOR THE COMING SEASON.

MESSENGER'S **SHADOWLESS** BURNER.
(PATENT)
WITH **VITREOSIL** DISH
AND 3 LIGHT SUPERHEATED NOZZLE TO TAKE 3 MEDIUM SIZE MANTLES.

There is no risk of broken Dishes so often caused by broken Mantles.
As Fireproof as Asbestos.
Great reduction in outlay on renewals of Dishes and Mantles.
First cost the only cost.
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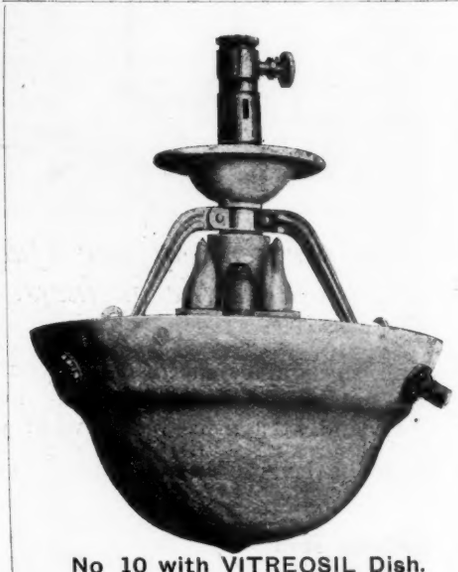

No 10 with VITREOSIL Dish.

One of the three points of support can be easily disengaged, giving perfect access to the Burner and inside of Dish for cleaning purposes.

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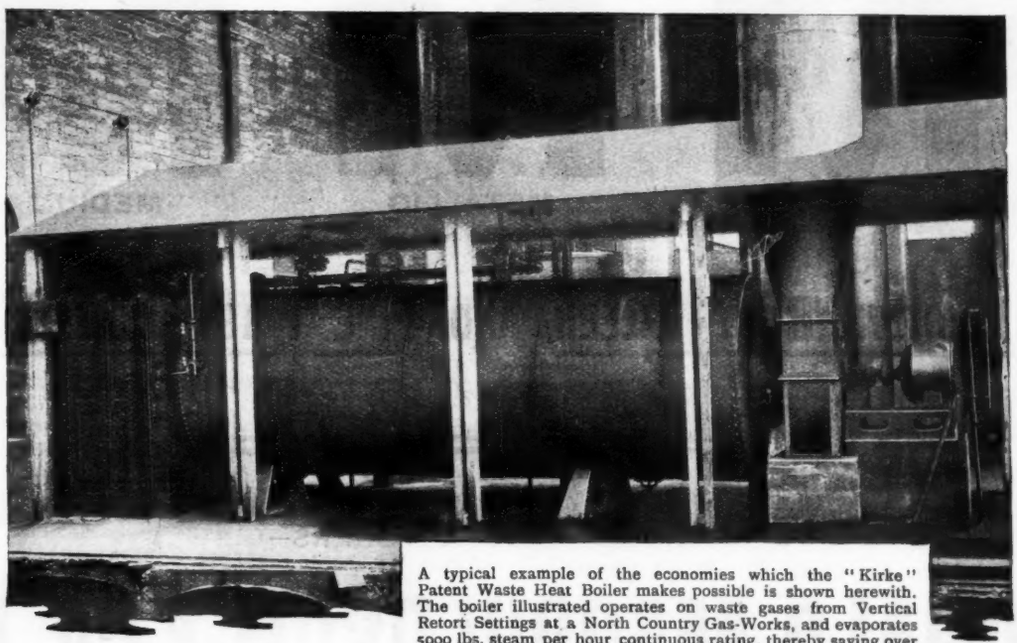

A typical example of the economies which the "Kirke" Patent Waste Heat Boiler makes possible is shown herewith. The boiler illustrated operates on waste gases from Vertical Retort Settings at a North Country Gas-Works, and evaporates 5000 lbs. steam per hour continuous rating, thereby saving over 2000 tons of coal per annum, which latter would be required as fuel for steam raising purposes if coal-fired boilers were used.

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Arden Hill's "NEW ACME" Gas Cooker—

The general belief that a thoroughly efficient Hotplate invariably results in its more generous use, has found practical demonstration in Arden Hill's "NEW ACME" Cooker. Users are loud in praise of the new "Eagle" Hotplate now fitted to this cooker, which is a tremendous advance over older types.

The oven is enamel lined inside and out and the door also has a green enamel outer plate, giving a bright and attractive appearance to the cooker.

¶ *Illustration below shews the New "Eagle" Hotplate as fitted to "New Acme" No. E483 which gives unprecedented economy and a well-aërated, intensely hot flame, properly centred on the cooking utensil.*

Price Lists gladly sent by —

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—with new HIGH EFFICIENCY HOTPLATE

WE SPECIALIZE IN

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SOLICIT ENQUIRIES FOR COMPLETE WORKS
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Only First-Class Materials and Workmanship.

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Cut down your Maintenance Costs

The
FLETCHER
"N.T. PALATINE" No. 165

The Ideal Cooker with High-Efficiency Hotplate

The HOTPLATE is designed on the unit principle. Each unit is so calculated, that the burner it contains, either for boiling or grilling, develops it maximum Efficiency. In this way the number of patterns is reduced to a minimum, therefore the stock of replacement parts is reduced. All burners are fitted with Gas and Air Adjusters.

The OVEN is double cased, packed with slag wool between the sheet steel side and back plates, which are coated with green Porcelain Enamel inside and out. All Shelf rests and interior fittings are removable for easy cleaning.

WE BENEFIT by Economy in Production.
YOU BENEFIT by Economy in Maintenance.
YOUR CONSUMER BENEFITS by Economy in Use.

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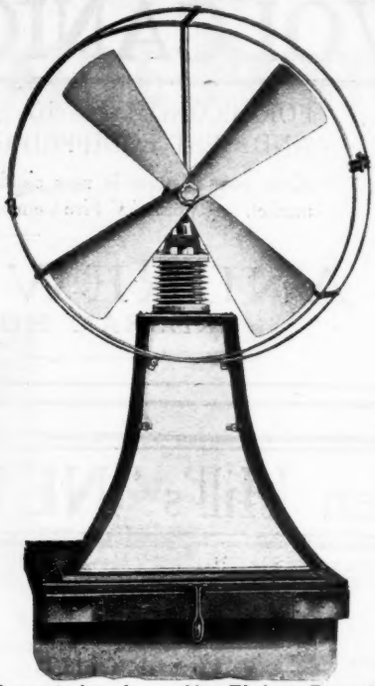

Self-contained. No Fixing Required.
Only requires coupling up to Gas Burner with Flexible Tube.

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ALL THE PRINCIPAL GAS WORKS IN THE KINGDOM USE
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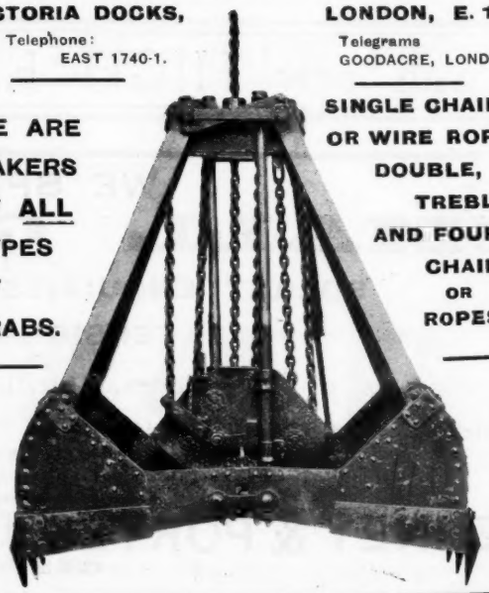

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Aluminium superheater intensifies the light with less consumption of gas.

Takes 3 Bijou Mantles and Standard Size Globe.

3/9 EACH **42/-** DOZ.

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Our Prices of GLASS and BURNERS NOW GREATLY REDUCED. *List sent on application.*

SEE OUR EXHIBITS at Stands Nos. 115 & 138 at the

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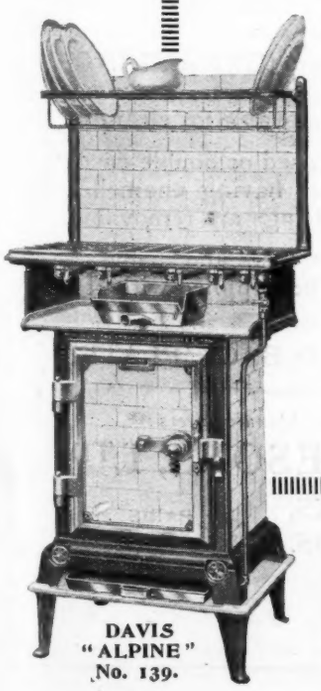

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Davis' have all along believed that the more economical the cooker can be made, the more frequently it will be used, with a consequent benefit both to consumer and gas undertakings. Their new "Alpine" series crystallizes all their long experience in burner design into a model that is having amazing success wherever it has been introduced.

The DAVIS "ALPINE" *Series of Cookers*

¶ *Fitted with the Davis Efficiency Hotplate and mounted on legs and stand. White enamelled sides and door as illustrated. Send for price lists and full particulars.*

Made in THREE SIZES

Specially suitable for HOUSING SCHEMES

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Front View (cover removed).

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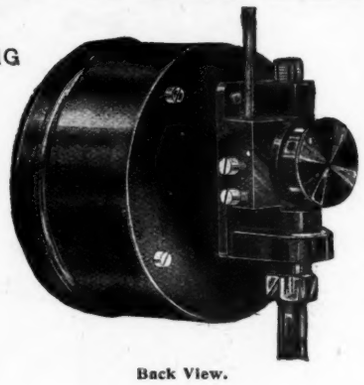

Back View.

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PREPARE NOW

FOR 1922-1923
LIGHTING SEASON

ON THE BASIS OF ECONOMY & EFFICIENCY.

Write To-Day for Particulars and Descriptive Booklet.

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See also Advertisement on p. XI.

The "GEM" SMALL HOUSEHOLD COOKER.

A complete Gas Cooker on a reduced scale but perfect in every part.

HOT PLATE fitted with three burners (**GRILL, RING,** and **SIMMERING**), all parts, including the top bars, being removable for cleaning.

OVEN is made either single-cased or double-cased and packed (the latter having enamelled linings). All inside fittings are removable.

STAND raises the Cooker 11 ins., and being a separate portion, can be supplied with the Cooker if required.

PLATE RACK and ENAMELLED BACK PLATE.

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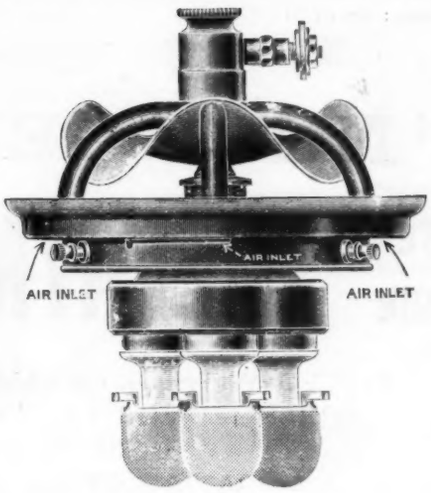
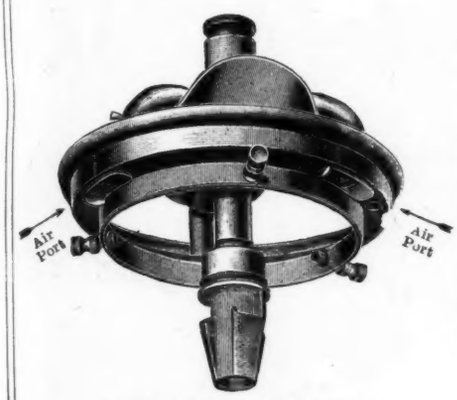
PATENTEES OF THE

Superheated Dustproof
BUNSEN (Domestic)
"IVEX" BURNER

BASED ON SCIENTIFIC PRINCIPLES.

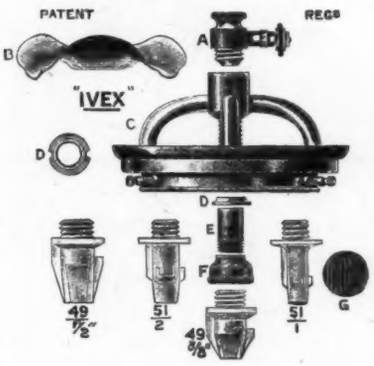




Fitted with No. 49 ½" bore nozzle.

DESCRIPTION.

A. Gas regulator.
B. Perdifume in aluminium or porcelain, made of 98% purity metal, 19 G.
C. Air inlet tubes.
D. Screwed washer.
E. Connecting to Bunsen tube.
F. To take mantle nozzle.
G. Nickel gauze if required.
49/½" Nozzle for ordinary size universal mantle.
51/2 Nozzle for medium size or No. 2 mantle.
52/1 Nozzle for Bijou size mantle.
49A/3/8" Short nozzle for 33 m.m. mantle for a short intensive flame, universal ring fitting.



EVERY detail has been carefully studied, and all parts are made from the very best material, and substantially built. The Bunsen Tube is made from solid brass rodding. The Air Tubes are made of seamless Brass tube 18 W.G. The Connecting Tube E is of seamless Brass tube. The nozzle F is made from solid rodding metal. The Gauze G is of pure Nickel, which it is not always found necessary to use, and fits in part F.

The Nozzles or Mantle Holders are of the very best quality, material and finish, and are all interchangeable in the same Burner for different size mantles, each nozzle being provided with a stop so that the mantle can only be put on and taken off one way.

Part B, Perdifume, is made of Aluminium 98% purity, heat resistance 1159 F. Authority, Huntington and McMillan.

The Air to mix with Gas in Mixing Chamber is drawn through three tubes, each Tube being provided with a Shutter attached to Gallery or Corona Band, away from the products of combustion and below the level of outlet, thus always providing the Burner with Primary rich Air free from Air partly mixed with products of combustion. Each Air Port can be partially closed or left open, as shown in accompanying illustration of sliding shutter.

The maximum illuminating power is attained after the Burner has been in lighting a short time, when the Air drawn through the three Tubes has become heated. The Burner can be fitted with a fixed Nipple for a definite quantity of Gas only. One standard size Globe only required with any size mantle used.

We have varying size Nozzles for all qualities of Gas.

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(Branch of Meters, Limited),

Atlas Meter Works,

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"NEW CENTURY" IMPROVED PATENT COIN PREPAYMENT GAS-METERS

FITTED WITH DETACHABLE ATTACHMENTS
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SATISFACTION ASSURED.

Dry Meter in Tin Plate Case, fitted with Attachment.

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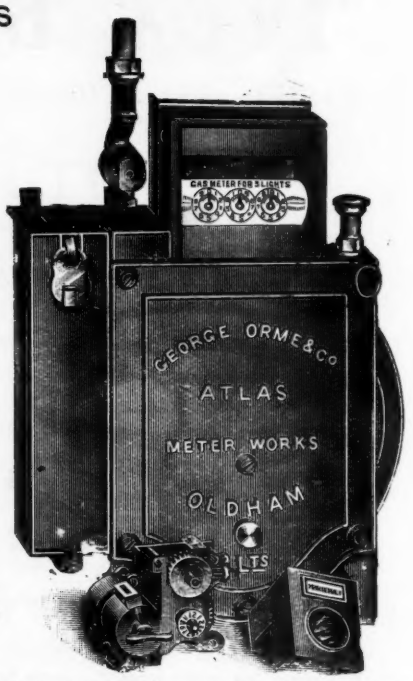

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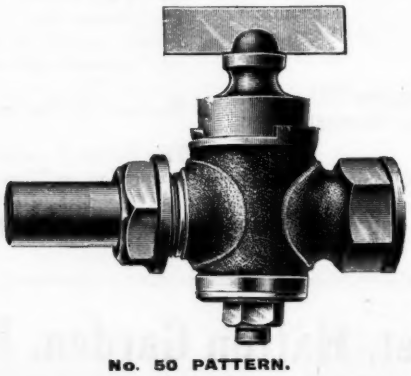
ALSO STEAM AND WATER FITTINGS OF THE VERY BEST QUALITY AND WORKMANSHIP.



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WE SOLICIT THE FAVOUR OF YOUR ENQUIRIES.

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CAST-IRON PIPES FOR GAS AND WATER MAINS

Also GENERAL CASTINGS FOR GAS-WORKS APPARATUS,

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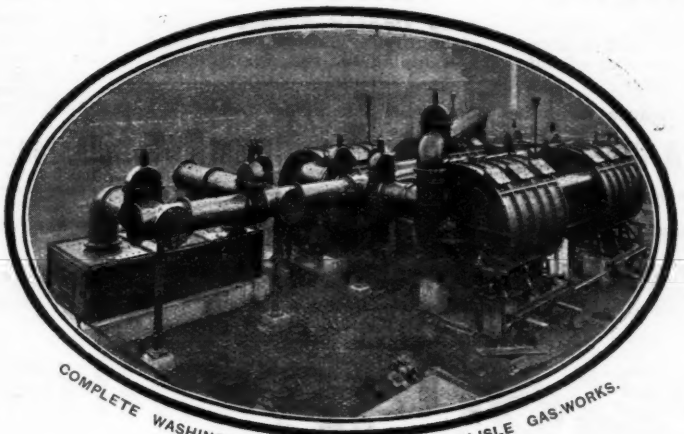

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LONGEST LIFE.

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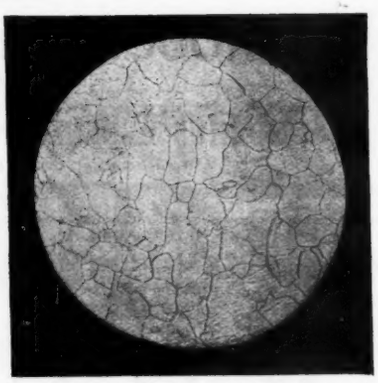

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Blue Annealed Plates—Absence of Pitting Corrosion—Working Quality—Uniformity—Welding Quality—Paint Holding Surface.

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Alloy Coated Sheets—Solder without Flux—Same Pure Iron Base—Stamping Quality—Resistance to Chemical Action.

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Our experience enables us to offer the most suitable plant for each particular case.

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SIMON MECHANICAL CONVEYING AND ELEVATING PLANT.

COMPLETE INSTALLATIONS DESIGNED & CONSTRUCTED.

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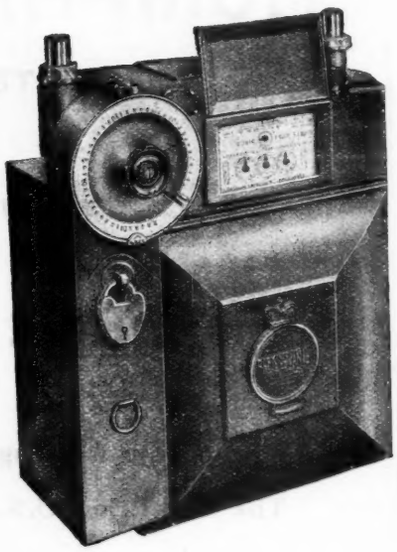

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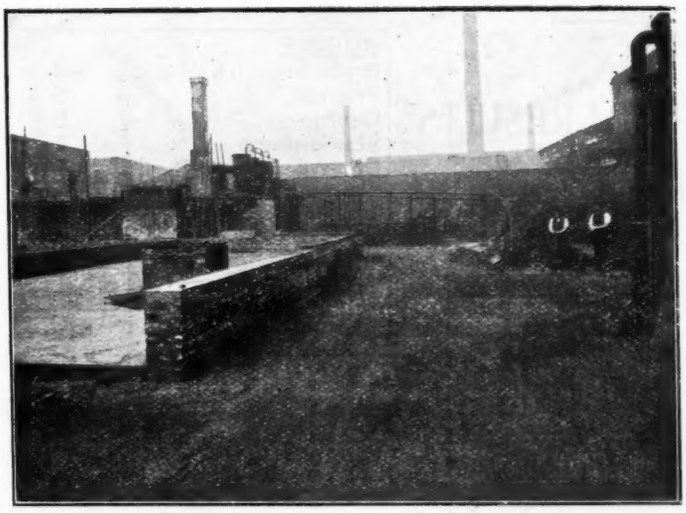

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PLANTS FOR TAR DEHYDRATION AND DISTILLATION AND REFINING OF PRODUCTS DESIGNED AND ERECTED TO SUIT INDIVIDUAL REQUIREMENTS.

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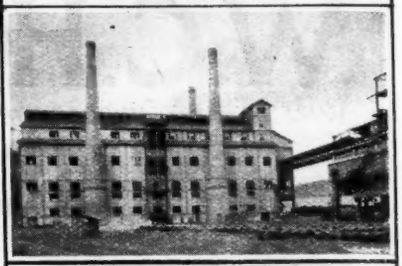

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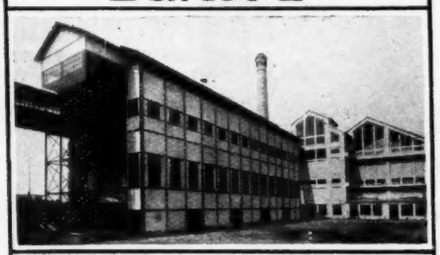
Capacity 270 Tons Per Day

MAXIMUM RESULTS WITH MINIMUM LABOUR

PARTICULARS OF PLANTS

	No. Installed	Capacity in Tons per day
EUROPE		
Great Britain & Ireland	93	12,236
France	5	742
Germany	5	500
Scandinavia	7	408
Other Countries	2	160
	112	14,046
ASIA	2	220
AFRICA	1	35
AMERICA	14	882
AUSTRALASIA	11	820
TOTAL	140	16,003

EUROPE



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SIMPLICITY AND STRENGTH OF CONSTRUCTION

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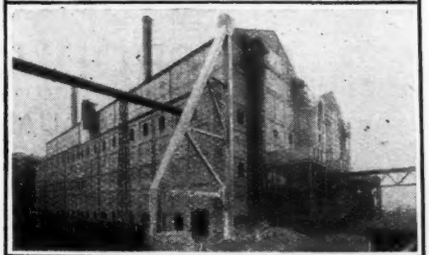

SCOTLAND – GLASGOW
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THE WOODALL-DUCKHAM VERTICAL RETORT

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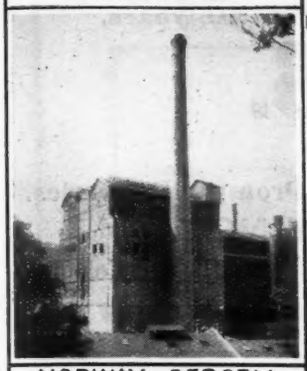

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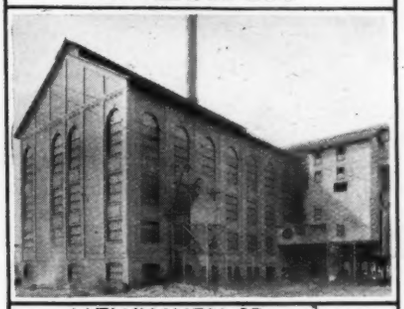

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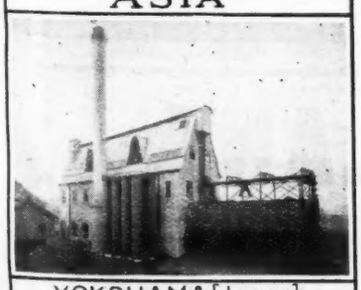

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Cutler's Patent "Steel-All" Carriage *for* Spiral Gasholders.

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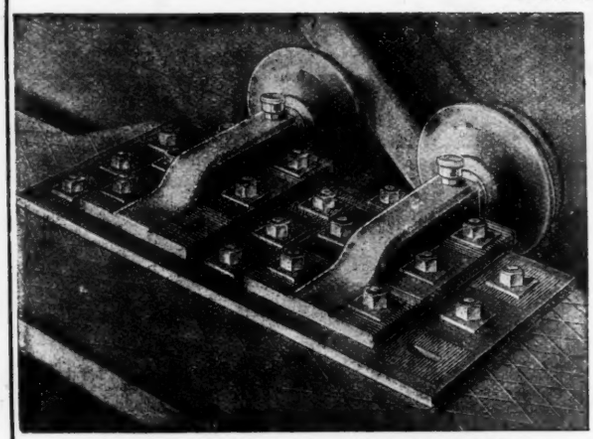

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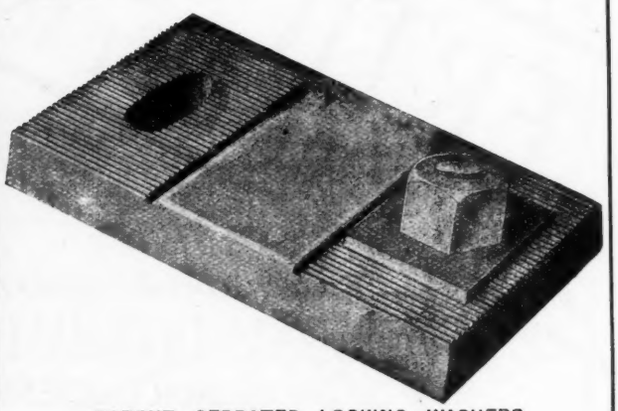

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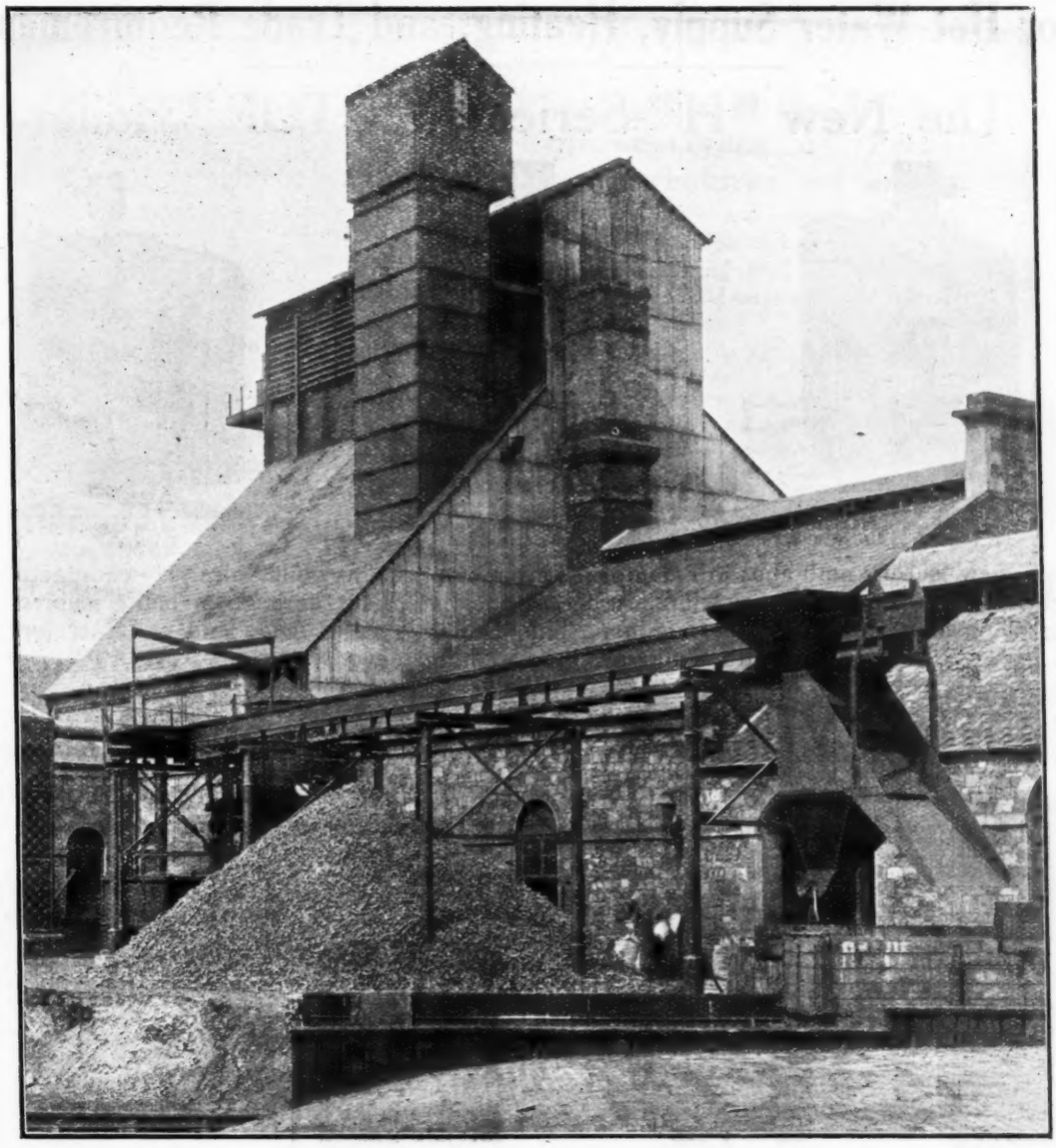
"DEMPSTER-TOOGOOD" SYSTEM OF (STEAMED) CONTINUOUS VERTICAL RETORTS.



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"As a penalty is attached in the Act on the gas manufacturer if he fails to maintain the declared calorific value, it is imperative that our carbonizing processes should go forward as regularly and continuously as possible, and our vertical retort plant is certainly a great success in this respect; results being consistently good, and with slight variations the plant responds almost immediately to the ordinary adjustments for the varying classes of coal. Choked off-take pipes, pitched hydraulics, hanging-up or running charges are things unknown to us. It is also apparent that the efficiency of the extractor device is of a very high order, when I tell you that during the strike period we carbonized, as an experiment, non-coking dross and 50 per cent. sawdust without the slightest signs of the charge slipping.

We have absolutely eliminated the formation of clinker in our producers; it is easy to maintain any desired temperature in our settings from day to day without variation; and it is unnecessary to false-bar the furnace for cleaning-out purposes.

Having regard to all the foregoing factors I had tests made on our vertical retort plant in order to discover what calorific value would most effectively suit our local conditions. From these tests the following table was compiled—taking cost of coal and yield from residuals at local prices, wages from coal wagon to coke store, and including supervision of machinery. In calculating the cost per therm, I may mention that coke available for sale under the different calorific values produced is a very important factor.

Table showing Cost of Therm Produced at Different Calorific Values.

(Scotch containing usual percentage of ash.)

	A	B	C
Coal carbonized, tons .	307	482	429
Gas produced, c.ft. . .	5,860,800	7,797,300	5,838,300
Gas made per ton, c.ft. .	19,090	16,176	13,141
Calorific value, gross . .	410 B.Th.U.	475 B.Th.U.	500 B.Th.U.
B.Th.U. per ton . . .	7,826,900	7,683,600	6,570,500
Therms per ton . . .	78·2	76·8	65·7
Cost of manufacture per therm, pence . . .	2·57	1·66	1 97
Duration of test . . .	1 month	1 month	1 month"

A. Dow, Esq., Galashiels,
Waverley Association Meeting of Gas Managers, June 8, 1922.

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Wire: DEMPSTER, ELLAND. **ELLAND.** 'Phone: ELLAND 261 262, 263

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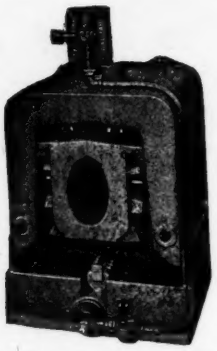
for Hot Water Supply, Heating, and Trade Requirements

The New "H" Series "VICTOR" Boiler

"H" Series Boiler complete.
No. 92 (60 c.ft.) £9 15 0
No. 93 (80 c.ft.) £11 0 0



Showing the front plate and manhole cover removed ready for cleaning *in situ*.

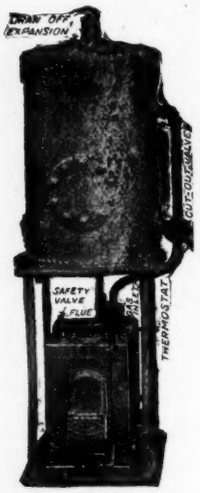
The back view showing the simplicity of the single coupling.

This new series embodies all factors of importance in boiler design—compactness, lightness, easy maintenance, and low costs, the list prices here given being subject to liberal discount to Gas Undertakings. This Boiler is 12 in. wide and will therefore fit into a narrow recess alongside cooker.

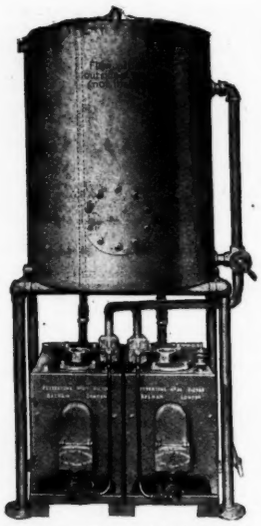
The "VICTOR" Complete Apparatus.

For new installations and converted tank systems these complete sets are recommended.

The complete apparatus with "H" Series Boiler and rectangular storage, width 12 in.
No. 921, £19 10 0
No. 931, £23 0 0



The complete apparatus with "D" Series Boiler and circular storage.
No. 10 .. £24 0 0
No. 11 .. £26 5 0



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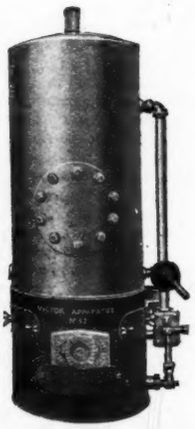
Quotations for any combination are given upon request.

Fully Illustrated Catalogue sent upon request.



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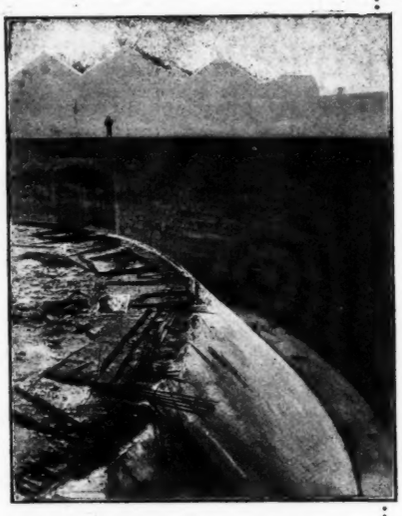

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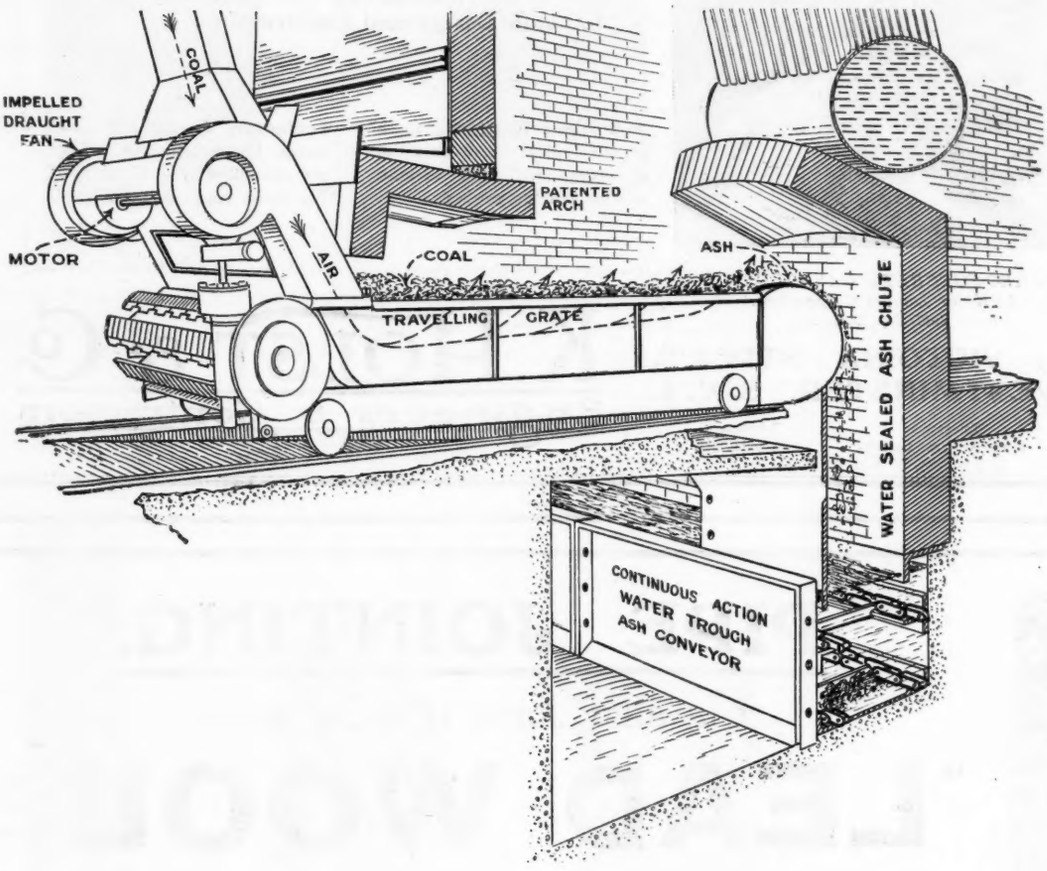

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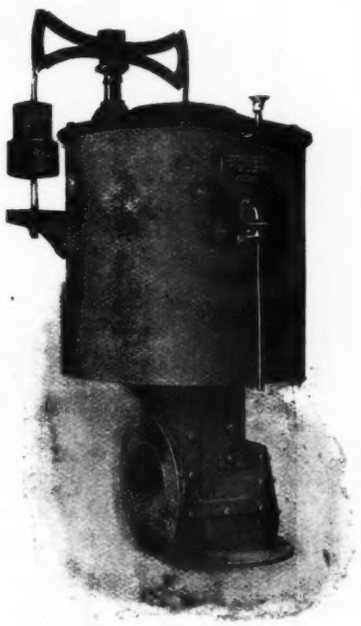

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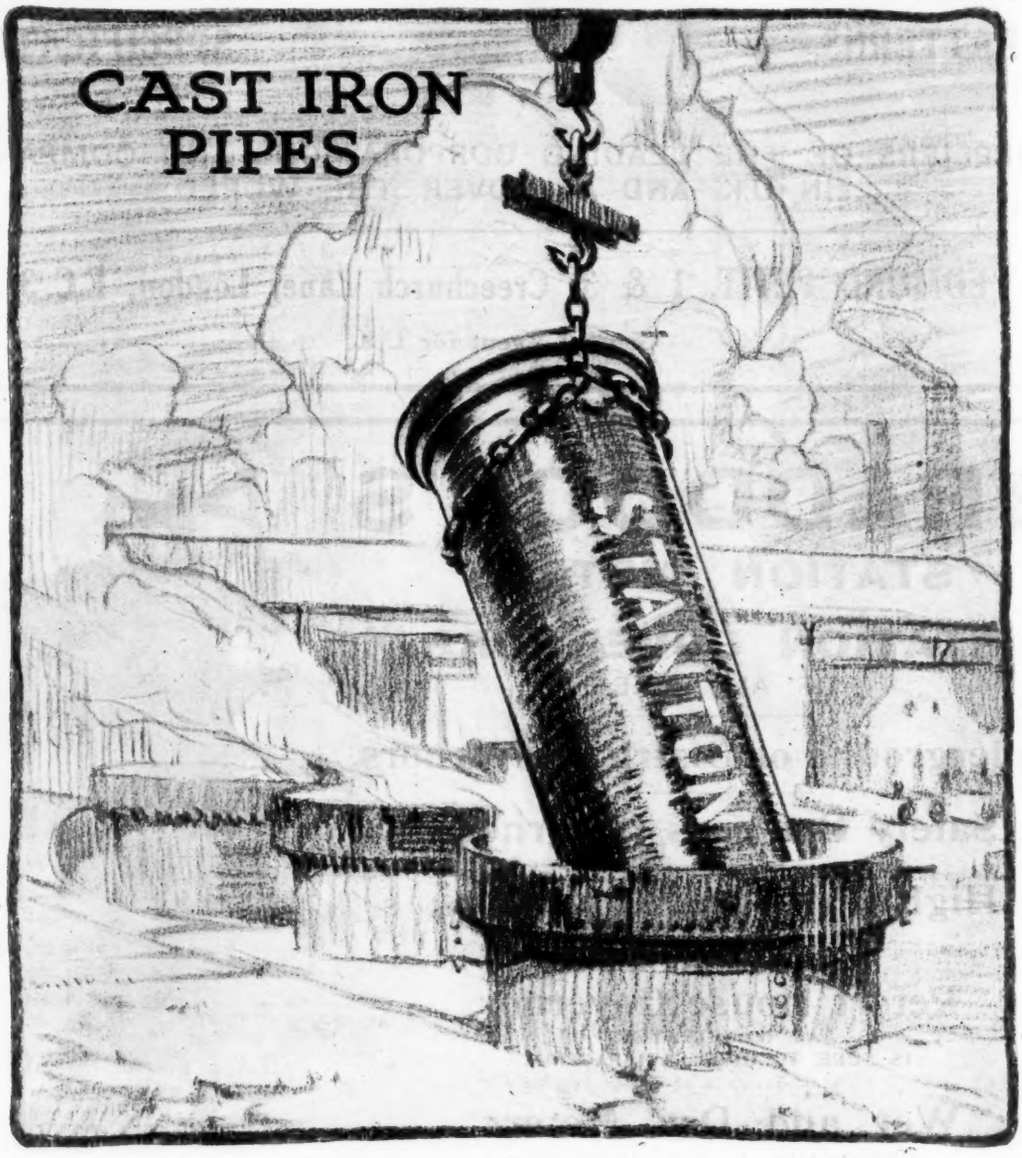

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The most Efficient Coke-Fired H.W. Boilers made to meet all Modern Requirements.

"GLOW-WORM" HOT WATER BOILER.

THE MOST SUCCESSFUL SUBSTITUTE FOR THE KITCHEN RANGE BOILER.

The Original and only Boiler of this Design with really efficient Hot Plate and Abundant Hot Water Supply (gives a Hot Bath every 15 minutes). Inexpensive and most economical, and will consume Household Refuse.

The Fire is always visible; Drop door to show Open Fire, and to provide Trivet; with use of Hopper will keep alight all night.

Radiators and Towel Rail can also be connected.

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IN ACCORDANCE WITH THE

NEW STANDARD LIST

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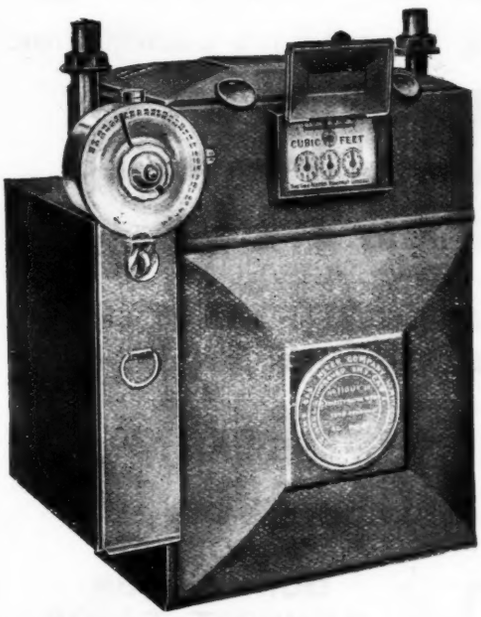

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Self-contained Change Plate

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Positive Gearing. Large Cash Box. Strongly Made.
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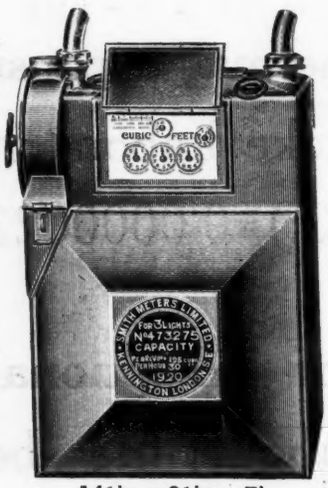

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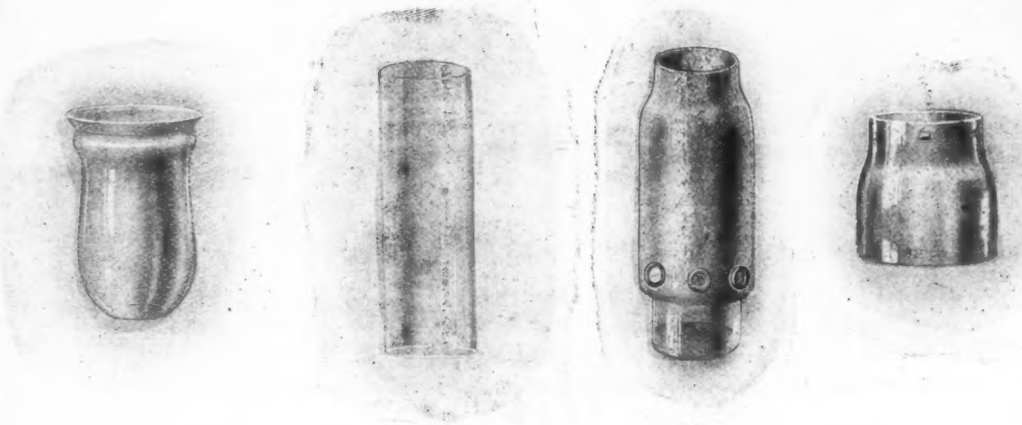

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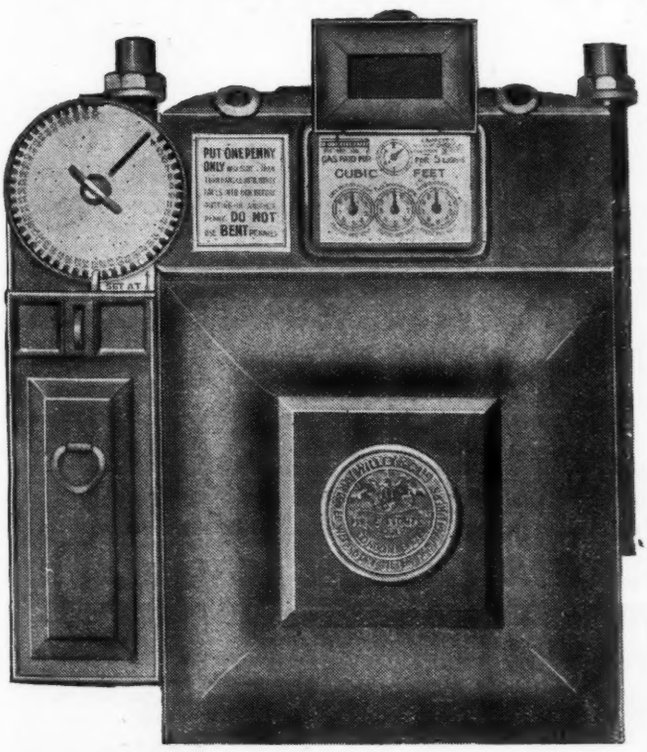

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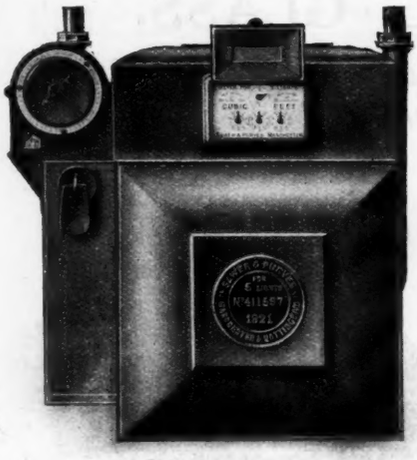

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